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TABLE OF CONTENTS

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1892—1950

Karam Chand Mehta

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KARAMCHAND MEHTA, 1892-1950

IN the death of Karamchand Mehta at Agra on April 8, 1950, India has lost an eminent botanist and the world an outstanding investigator of cereal rusts.

Born at Amritsar on June 20, 1892, Mehta received his early education at the local schools. At the Government College, Lahore he came under the influence of Prof. Shiv Ram Kashyap, the fore-most Indian botanist of his time. He took the Master's degree in 1914, receiving the Arnold Medal for topping the list of successful candidates. Next year he joined Agra College as Assistant Professor of Botany and served that Institution till the end of his life. He went to Cambridge in 1920 to work under the guidance of Prof. F.T. Brooks, then Reader in the Botany School, and carried out comprehensive studies on cereal rusts and was awarded the Ph. D. degree in 1922. On his return, he became the Professor of Botany and Head of the Biology Department of Agra College in 1923 and rose to the office of its Principal in 1945. In 1944 he was elected Dean of the Faculty of Science of Agra University. He was a member of the Governing Body of the Birbal Sahni Institute of Palæobotany and of the Plant Pathology and Food Grains Policy Committees of the Government of India.

Following the important contributions by Butler, and Butler and Hayman in 1906, the 'baffling' wheat-rust problem remained neglected for several years. On his return from Cambridge, Mehta, therefore, decided to undertake further investigations in this field and devoted all his spare time to this work, unaided by men or money for a long period and at considerable personal expense. In April, 1930, however, the Indian Council of Agricultural Research came to his aid with a handsome grant and under his guidance the cereal rusts of India were studied from all aspects at the Rust Research Laboratories, Simla and Agra. Whatever information we now possess on the physiology and epidemiology of wheat and barley rusts in this country, we owe largely to the pioneer work carried out by him. In 1935, in cooperation with the Imperial Economic Botanist (now Head of the Division of Botany), Indian Agricultural Research Institute, work was started on the breeding of wheats resistant to rusts.

Mehta presided over the Botany Section of the Indian Science Congress which met at Madras in 1929 and delivered a very challenging address on the 'Annual Recurrence of Rusts of Wheat and Barley in India' wherein he declared that the origin of these rusts, following the hot summers in the Indian plains through which neither wheat nor its rust can survive, could be traced to

the hills where they oversummer on 'out-of-season' wheat and barely plants and cause early rust outbreaks on the local crop. He showed that winds from the hills carry the infection to the plains. In 1930, he was invited by the International Botanical Congress, held at Cambridge, to read a paper on his work on rusts in India and take part in a discussion on "The dissemination of Cereal Rusts". In 1940, the Indian Council of Agricultural Research published a Scientific Monograph on 'Further Studies on Cereal Rusts in India' based on the results obtained in his laboratories on 'Physiologic races', 'Role of alternate hosts' and 'Oversummering in relation to Annual Recurrence'. The data presented in this Monograph fully bear out his earlier contention that the foci of infection lie in the hills, and *Berberis* and *Thalictrum*, the alternate hosts of black and brown rusts, respectively, play little part in the annual origin of those rusts in the plains. Largely on this contribution, the University of Cambridge awarded him their highest distinction of Sc.D. in 1941. He was the first, and so far the only person from India to receive this distinction for researches in the field of Plant Pathology. Another Monograph dealing with Dissemination of Rusts is in the press which, according to Prof. F.T. Brooks, "is a most notable work, and nothing comparable to it has been produced in any country where cereal rusts have been studied intensively. The detailed study of wind trajectories in relation to spore showers and rust outbreaks is unique and is of great scientific and practical value".

Mehta was one of the Foundation Fellows of the National Institute of Sciences of India, a Fellow of the National Academy, Allahabad, and the Indian Academy of Sciences, Bangalore, President of the Indian Botanical Society for 1939, and a Charter member and Vice-President of the Indian Phytopathological Society. He was awarded the Barclay Memorial Medal by the Asiatic Society of Bengal in 1948. In 1949, he was invited to delivery the 11th Acharya Jagadish Chandra Bose Memorial Lecture on the occasion of the 32nd anniversary of the Foundation of the Bose Institute, Calcutta, where he spoke on 'Control of rust epidemics of wheat in India—a national emergency'.

Ever since he started investigations on cereal rusts in 1923, Mehta threw himself heart and soul in finding measures to control rust epidemics in India, a problem which had baffled many eminent scientists. There was no Sunday or holiday for him. Every summer vacation from his college he would journey to the hills and work at his Simla laboratory. He worked with a missionary zeal, entirely in an honorary capacity, knowing no rest himself nor giving any to his associates. That was, as he put it, his humble contribution to the cause of Science and service to his Motherland.

As remarked by Sir John Russel, "He wisely kept to one problem, and so was able to make more progress than if he had scattered his energies in several directions". As a result of his researches extending over a period of 27 years, he recommended simple and practical measures for controlling wheat rusts in India. His plan was to tackle the parasites at the source, i.e., the hills. With strict enforcement of the prohibition of the summer crops of wheat and barley in Peninsular India and by the replacement of these crops in the hills and hilly tracts, which are acting as foci in the north and potential foci for the central parts of the country, by oats fit for human consumption, we should, according to him, be able to avert largely the danger of serious epidemics. Following the severe rust outbreaks in 1946-47, the Government of India constituted a Rust Control Committee to examine the whole position which decided to try his methods on a small scale in Peninsular India. His manifold duties as Principal of a College, as Dean of the Faculty of Science and the rust research put a heavy strain on his health during the last ten years, but ignoring the advice of his physicians and friends, he continued to over-work. He had a serious illness in April, 1949, and was advised complete rest. However, paying no heed to his personal comfort or safety, he went again early this year to South India, to personally supervise rust control measures. The tour proved too strenuous for his age and health and he had yet another attack of illness soon after his return. His indomitable will and the personal attention of his wife, and physician son and daughter pulled him through, but unfortunately he could not survive long. He had yet another attack of illness from which he could not recover. He passed away on April 8, 1950, leaving behind his devoted wife, a son, three daughters and a host of friends and pupils to mourn his loss.

Mehta was a strict disciplinarian and his students regarded him with a mixture of love, awe and respect. Unsparing of himself, he expected both from his colleagues and students the highest degree of efficiency. He was a dreamer of a rust-free India and to that end he dedicated his life.

R. PRASADA

GENERA OF RUSTS III

M. J. Thirumalachar and B. B. Mundkur
(Accepted for publication September 1, 1950)

91. POLIOTELIUM Sydow in *Ann. Mycol.*, 20, p. 124, 1922
=*Uromyces* Link-?

Pycnia subepidermal. Aecia cupulate and peridiate; aeciospores developing in chains. Telia subepidermal, erumpent; telio-spores one-celled, pedicellate, clavate-cylindric, thin-walled, with an apical germ pore, through which promycelium extrudes; promycelium external, four-celled, bearing globular sporidia.

Type species: *Poliotelium iresines* (Lagerh.) Syd. on *Iresine* sp. (Amarantaceae)

Distribution: Central and South America (3 species)

Notes: Sydow based the genus on the basis of the life-cycle. According to him *Poliotelium* differed from *Argomycetella* in having only aecia and telia as against uredia and telia in the latter. Since life-cycle variants do not offer any basis for generic differentiation, Dietel (1928) merged *Poliotelium* as a synonym of *Argomycetella* (=*Maravalia*). Arthur (1926) treated it as a synonym of *Pucciniola*. However, Mains (1939)who made a comparative study of species of *Maravalia* (including those placed under *Argomycetella*) was inclined to separate *Poliotelium* as a separate genus on account of the presence of distinct germ pores in the latter. Unlike *Maravalia*, the promycelium in *Poliotelium* is not the prolongation of the spore apex; it escapes out through a distinct germ pore.

While this character certainly separates it from *Maravalia*, its differentiation from species of *Uromyces*, (which often have subhyaline teliospores and always possess distinct germ pores) is rather difficult. *Poliotelium* bears the same relationship to *Uromyces* as *Eriosporangium* does to *Puccinia*. We are of the opinion, that when a larger number of species is studied (which is highly desirable), *Poliotelium* may prove to be synonymous with *Uromyces*.

Arthur, J. C. (1926)	N. Am, Fl., **7**: 794
Dietel, P. (1928)	Die naturlichen Pflanzenfamilien, **6**: 77
Mains, E. B. (1939	*Bull. Torrey Bot. Cl.*, **66** 174-175

92. PROSPODIUM Arthur In *J. Mycol.* **13**, p. 31, 1907. Fig. 84
Syn. *Coinostelium* Sydow, *Ann. Mycol.* **37**: 308, 1939
Nephlyctis Arthur, *J. Mycol.* **13**:31, 1907

Pycnia subcuticular, conoid, applanate, with ostiolar filaments. Aecia (primary uredia) uredinoid, subcuticular, aparaphysate or paraphysate; aeciospores similar to the urediospores that follow. Uredia subepidermal and erumpent by the rupture of the epidermis, or superstomal (extra-stomal according to Cummins) formed above the epidermis by strands of hyphae emerging through the stomata; sori of the latter type surrounded by a marginal fringe of paraphyses forming a peridial cup; urediospores pedicellate which are grouped in fascicles with two equatorial germ pores; wall layer of the urediospores nonlaminate or bilaminate and unicapitate or bilaminate and bicapitate. Telia similar to uredia; either subepidermal or superstomal; teliospores produced as the urediospores, *Puccinia*-like with a single germ pore in each cell; pedicel hyaline or tinted, fasciculate, often hygroscopic, variously appendaged, and rarely unadorned: appendages as hyaline or subhyaline umbo or papilla.

TYPE SPECIES: *Prospodium appendiculatum* (Winter) Arthur, on Bignoniaceae.

DISTRIBUTION: Known so far only in the tropical and subtropical region of Western Hemisphere (54 species)

NOTES: The genus was founded by Arthur for a rust on Bignoniaceae, and all the species so far known are restricted to Western Hemisphere.

Uredo stereospermi Syd. on *Stereospermum* sp. in Ceylon showed superficial resemblance to *Prospodium* in the laminate character of the spore wall but since the discovery of the telia by Thirumalachar and Mundkur (1945) this rust is now known to belong to a different genus.

A monograph on the genus *Prospodium* has been published by Cummins (1940). The various species are parasitic on species of the families Bignoniaceae and Verbenaceae.

The superstomal nature of the uredia and telia in some species of the genus was first pointed out by Cummins (1937). These are similar to those found in species of *Crossopsora*, *Anthomycetella*, *Olivea* and others. The superstomal or subepidermal nature of the uredia and telia in itself may not be of much value in separating genera as pointed by Cummins also. Several other genera of rusts have subepidermal and superstomal uredia and telia such as *Hemiliea*,

and *Mainsia*. For this reason the genus *Coinostelium* established by Sydow (1939) on a verbenaceous host is treated as synonymous with *Prospodium*. The genus *Nephlyctis* of Arthur erected for accomodating microcyclic species of *Prospodium* is also treated as a synonym.

On the basis of superstomal or subepidermal nature of the sorus and the macro- or micro-cyclic nature of the life-cycle, Cummins subdivides the genus into three sections: (10) *Euprospodium* for macrocyclic species with subepidermal uredia and telia, (2) *Cyathopsora* for macrocyclic species with superstomal uredia and telia and (3) *Nephlyctis* for all microcyclic species.

The subcuticular nature of pycnia in *Prospodium* separates it from *Puccinia* where they are subepidermal. *Uropyxis* also possesses subcuticular pycnia and has species parasitising members of Bignoniaceae. The occurrence of two lateral germ pores in each cell of the teliospore in *Uropyxis* separates it from *Prospodium*.

ARTHUR, J.C. (1925). N. Amer. Fl. **7**: 160-163
CUMMINS, G.B. (1937) *Ann. Mycol.* **35**: 15-21
CUMMINS, B. B. (1940), *Lloydia* **3**: 1-78
DIETEL, P. (1928). Die natürlicnen Pflanzenfamilien. **6**: 65
THIRUMALACHAR M. J. AND MUNDKUR, B. B. (1949). *Indian Phytopath* **2**: 65-101.

93. PUCCINIA Persoon in (*Dips. Meth. Fung.* p. 38, 1797), *Syn. Meth. Fung.* p. 225, 1801 Fig. 85.

Syn. *Allodus* Arth. in *Result. Sci. Congr. Internat. Bot. Wien*, 1905, p. 345, 1906
Bullaria D. C. in *Flore France*, **2**: 226, 1805
Coronotelium Sydow in *Ann. Mycol.* **19**: 174, 1921
Cutomyces Thuem. in *Journ .Sci, Math. Phys. Nat. Lisboa*, **6**: 239, 1876
Dicaemoa S. F. Gray in *Nat. Arr. Brit.* Pl. I, p. 541, 1821
Eriosporangium Bertero ex Leville, in *Ann. Sci. Nat. Bot.* III Ser., **5**: 249, 1846
Jackya Bubak in *Ost. Bot. Z.* **1**: 42, 1902
Leptinia Juel in *Bih. Svensk. Vetens. Akad. Handl.* 23, Afd. 3, No. 10, p. 15, 1897

Leptopuccinia Rostrup in *Plantopatologi*, p. 208, 1902
Lindrothia Syd. in *Ann. Mycol.* **20**: 119, 1922
Linkiella Syd. in *Ann. Mycol.* **19**: 173, 1921
Lysospora Arth. in *Result Sci. Congr. Internat. Bot. Wien*, 1905, p. 340, 1906
Micropuccinia Rostrup in *Plantopatologi*, p. 220 1902
Peristemma Syd. in *Ann. Mycol.* **19**: 175, 1921
Persooniella Syd. in *Ann. Mycol.* **20**: 118, 1922
Pleomeris Syd. in *Ann. Mycol* **19**: 171, 1921
Poliomella Syd. in *Ann. Mycol.* **20**: 122, 1922
Pseudopuccinia Hohnel apud Weese in *Mitt. Bot. Lab. Tech. Hochsch. Wien*, II, p. 41, 1925
Puccinidia H. Mayr. in *Waldingen Nordamerika*, p. 337, 1829
Rostrupia Lagerh. in *J. Bot. Paris*, **3**: 188, 1889
Schroeterella Sydow in *Ann Mycol.* **20**: 172, 1922
Sclerotelium Syd. in *Ann.Mycol.* **19**: 172, 1921
Solenodonta Castagne in *Cat. Pl. Marseille*, 202, 1845
Trailia Syd. in *Ann. Mycol.* **20**: 121 1922

Pycnia subepidermal, cupulate, ostiolate, with ostiolar paraphyses. Aecia subepidermal, cupulate, erumpent, pulverulent and peridiate; peridia well developed or evanascent; aeciospores produced in chains, angularly globoid or spherical. Uredia subepidermal, with or without paraphyses; urediospores produced singly on pedicels. Telia subepidermal, mostly replacing the uredia when they are present; teliospores 2-celled, pedicellate, reddish-brown to pale yellow in colour and rarely tending to be almost hyaline; septum horizontal, rarely oblique and even vertical; germ-pore single in each cell, usually apical in the top cell and lateral in the lower one; teliospores germinating after a period of rest or immediately, promycelium external, typically 4-celled, or 2-celled, or irregular.

TYPE SPECIES: *Puccinia graminis* Pers. is taken as type by Clements and Shear and also Cunningham. (Several families)

DISTRIBUTION: Widespread. (Over 2,000 species known)

NOTES: The genus includes several species of great economic importance which cause serious damage to cereal, vegetable, ornamental and other plants. It includes both autoecious and heteroecious forms which show great variability in the type of life cycle. The various species show intergrading of characters in the colour and resting type of teliospores as well as the extent of development of peridium within the aecium. Teliospores in some species are thin-walled, and hyaline while those of others are deep reddish-brown and are

resting spores. As already discussed before, the genus *Eriosporangium* should not be maintained as distinct from *Puccinia* because of the evanescent nature of the peridium.

The occurrence of the mesospores in rather large numbers in some cases has resulted in some of the species of *Puccinia* being mistaken for *Uromyces*. Even so, several cases of teliospores with more than 2 cells within have been recorded in species of *Puccinia*. This feature should not be given undue importance if they occur associated with normal two-celled teliospores typical of *Puccinia*. Some of these teratological phenomena have been cited by Arthur *et al*. The genus *Rostrupia* Lagerh. shows this type of variation and possesses more than two-celled teliospores in association with 2-celled ones. Dietel recognises this as a valid genus, but considering the range of variability, it is best to treat it as a synonym of *Puccinia*.

There is complete intergradation between *Puccinia* and *Diorchidium*, so that the separation of the genera showing oblique septation, laterally disposed germ pores and other intermediate characters, is only arbitrary.

The number and disposition of the germ pores separate *Puccinia* from *Cumminsiella* and *Stereostratum*, being two and lateral in *Cumminsiella* and 4 to 5 in *Stereostratum*. The subcuticular nature of the pycnium differentiates *Sorataea* and *Uropyxis* from the subepidermal condition present in *Puccinia*. The occurence of a stockade of peridia surrounding the telium is the only differentiating character of *Miyagia*

ARTHUR, J. C. (1934) Manual of Rusts etc. p, 100-101
ARTHUR, J. C. et al. (1928) Plant Rusts
DIETEL, P. (1928) Die naturlichenpftanzen femilien, 6; 84
DOIDGE, E. M. (1926) *Bothalia, 2:* 49
SYDOW, P. & H. (1904). Monogr. Ured I

94. **PUCCINIASTRUM** Otth in *Mitteil Naturf. Ges. Bern*. 1861, p. 71
Fig. 86

Syn. *Phragmopsora* Magnus in *Hedwigia*, **14:** 123, 1875
Pomatomyces Oerst in *Vid. Medd. Naturh. For. Kjobenhavn*, p. 249,
Thekopsora Magnus in *Hedwigia*, **14:** 123, 1875 1863

Pycnia subcuticular, often deeply sunken, without conspicuous ostiolar paraphyses. Aecia subepidermal, erumpent, cylindrical and peridiate; aeciospores in chains, globoid. Uredia subepidermal, minute, erumpent, surrounded by

a hemispherical peridium and opening by a small pore; the cells surrounding the orifice are larger and of various shapes; urediospores borne singly on short pedicels. Telia subepidermal, non-erumpent intercellular, crustaceous; teliospores spherical to oblong, mostly 2-to-many-septate, vertically or obliquely, smooth, coloured, germinating to form 4-celled external promycelium.

TYPE SPECIES: *Pucciniastrum epilobi* Otth on *Epilobium* sp. (Saxifragaceae)

DISTRIBUTION: South Africa, North America, Europe, Japan, India, and other places (20 species)

NOTES: The genus includes heteroecious rusts, with pycnia and aecia on *Abies* and uredia and telia on various dicots. The genera *Calyptospora* and *Thekopsora* have been treated as synonyms of *Pucciniastrum* by Arthur (1934). The development stages of the telia have been investigated cytologically by Pady (1933). *Thekopsora* differs from *Pucciniastrum* in the seat of teliospore development, being intraepidermal in the former and sub-epidermal and intercellular in the latter. The sub-epidermal or intra-epidermal nature of the telia by itself does not constitute a valid basis for separating the two genera, since similar instances of variability occur in such genera as *Mainsia*, *Hemileia*. etc. We therefore are in agreement with Arthur's treatment of the genus *Thekopsora* as a synonym of *Pucciniastrum*, though the former has become well established in rust literature. To indicate the differences in the mode of teliospore development, it seems feasible to reduce *Thekopsora* to the status of subgenus under *Pucciniastrum* and include these species with intra-epidermal telia under it.

ARTHUR, J. C. (1907).	N. Amer. Fl. **7**: 105
ARTHUR, J.C. (1934).	Manual of Rusts, p. 12
DIETEL, P. (1928).	Die natürlichen Pflanzenfamilen, **6**:40
..... (1938).	*Ann. Mycol.* **36**: 1-8
HIRATSUKA, N. (1936).	*Mem. Tottori Agric. Coll.* **4**: 1-374
PADY, S.M. (1933).	*Canad. J. Res.* **9**: 458-485
SYDOW, P. & H. (1915).	Monogr. Ured., III, p. 440

95 PUCCINIOSIRA Lagerheim in *Ber. Dtsch. Bot. Ges. 9*, p. 394, Fig. 87

Syn. *Aecidiella* Elb. & Kels. in *Bull. Torrey Bot. Cl., 24*: 208, 1897
Didymosira Clements in Genera of Fungi, p. 99, 1931
Schizospora Dietel in *Ber. dtsch. bot. Ges. 13:* 334, 1895

Pycnia subepidermal, flask-shaped, with ostiolar paraphyses. Aecia and uredia unknown. Telia subepidermal, erumpent, deep-seated, cupulate, and peridiate; peridial cells single layered, firm and evanescent: teliospores two-celled by transverse septation, sessile, hyaline or pale coloured, produced in chains in basipetal succession from the basal hymenium, often separated by sterile intercalary cells; teliospores germinating immediately without a rest period; promycelium external and four-celled.

TYPE SPECIES: *Pucciniosira triumfettae* Lagerh. On *Triumfetta sp.*(Tiliaceae)
DISTRIBUTION: South America, South Africa. (7 species)

NOTES: The telia are peridiate, develop chains of 2-celled sessile teliospores from the base of the sorus. In several species, there are distinct sterile intercalary cells seperating the teliospores so that the entire sorus can be homologous to an aecial cup. As stated under *Gambleola*, Jackson (1931) derives genera like *Didymopsora*, *Pucciniosira*, and others from *Endophyllum* like forms. There is some close resemblance between *Didymopsora* and *Pucciniosira*, but the latter has peridiate telia in contrast to *Didymopsora*.

ARTHUR, J. C. (1907). N. Amer. Fl. **7**: 126
DIETEL, P. (1928). *Die natürlichen Pflanzenfamilien*, **6**: 96
JACKSON, H. S. (1931). *Mem. Torrey Bot. Cl.* **18**: 1-108
SYDOW, P. & H. (1915). Monogr. Ured III: 538-542

96. PUCCINIOSTELE Tranzsch. and Komarov in *Arb. Nat. Ges. St. Petersb. 30*, p. 138, 1899. Fig. 88
Syn. *Klastopsora* Dietel in *Ann. Mycol.* **2**: 26, 1904

Pycnia subcuticular, flask shaped, Aecia subepidermal, caemoid, without peridium or paraphyses; aeciospores developed in chains and verruculose. Uredia subepidermal, erumpent, peridiate, Telia of two types; primary telia developing within the aecia or separately, crustose, waxy; teliospores united in discs or plates of four spores which are superimposed over one another in the telial crust and readily separating from one another into 4-celled discs. Secondary telia subepidermal, appearing as waxy yellow crusts, usually following the primary telia in development. Teliospores one-celled, developed in chains, 4-8 spores in a chain; spores firmly united with each other and giving the false appearance of phragmospores; spore chains coalesent laterally to form an umbonate crust; teliospore germination in either primary or secondary telia unknown.

TYPE SPECIES: *Pucciniostele clarkiana* (Barclay) Transz. & Komarov. (=*P. mandschurica* Diet.) on *Astilbe* sp. (Saxifragaceae)

DISTRIBUTION: India, Manchuria and parts of North eastern Asia including China. (3 species)

NOTES: *Pucciniostele* is a remarkable and interesting genus on account of the occurrence of two different types of telial stages in the life cycle of the rust. Such a condition is so far unknown in other rust genera. There is considerable ambiguity regarding the nature and role of the primary and secondary telia as no cultural studies have been carried out. Cummins and Thirumalachar (1949) who carried out studies on this genus from herbarium material. concluded that both the telial stages belong to the life-cycle of the same rust and that the secondary telium follows the primary one in development and is associated with it. They also observed that the primary teliospores are discoid or plate-like, formed by the union of tetrads of spores and not 2-celled and *Puccinia*-like as conceived by Dietel, who must have got the impression from the profile view of the telial crust. The teliospores in the secondary telium are one-celled and in firm chains and can be mistaken for phragmospores, which explains the tpye species being previously named *Xenodochus clarkiana* by Barclay.

In designating the type, Komarov and Tranzschel (1899) mistook the species they had for a separate species occurring in India which had been named by Barclay as *Xenodochus clarkiana*. Dietel corrected this error, and renamed the Manchurian species that Komarov and Tranzschel had designated as *P. mandschurica*, retaining the name *P. clarkiana* (Barclay) Diet for the Indian form.

The secondary telial stage of a species of the genus in association with uredia has been observed by Cummins on a member of the Vitaceae collected in China. The occurrence of subepidermal peridiate sorus in *P. clarkiana* was interpreted by Cummins & Thirumalachar as possible uredial stages of the rust.

CUMMINS, G. B. AND THIRUMALACHAR, M. J. (1950) *Mycologia* (in press)
DIETEL, P (1899) *Engl. Bot. Jb.* **27**: 564-576
..... (1904) *Ann. Mycol.* **2**: 20-26
..... (1928) Die natürlichen Pflanzenfamilien **6**: 94
KOMAROV, W. L. (1900) *Hedwigia* ,**39**: 121-123
SYDOW, P. & H- (1915) Monogr' Ured., III: 325

97. RAVENELIA Berkley in *Gardner's Chronicle*, *10*, p. 132, 1853. Fig. 89
Syn. *Cephalotelium* Syd. in *Ann. Mycol.* **19**: 165, 1921

Cystingophora Arth. in N. Amer. Fl. **7**: 131, 1907
Cystotelium Syd. in *Ann. Mycol.* **19**: 165, 1921

Dendroecia Arth. in *Result. Sci. Congr. Internat. Bot. Wien*, 1905, p. 340, 1906
Longia Syd. in *Ann. Mycol.* **19**: 165, 1921

Pycnia subcuticular, applanate and conoid, rarely subepidermal due to the overlying epidermal cells. Aecia when present subepidermal, cupulate, with well developed peridia or subcuticular and uredinoid, rarely with evanescent or without peridia and appearing caeomoid; aeciospores in the aecioid and caemoid types developing chains with or without sterile intercalary cells: those of uredinoid aecia resembling the urediospores that follow. Uredia subcuticular, intraepidermal or subepidermal, erumpent and pulverulent, paraphysate or aparaphysate, in which paraphyses are marginal or intermixed, germ pores equatorial or scattered. Telia like uredia; teliospores in heads of 3-30 spores, reddish-brown forming a firm and composite head, bearing hyaline and pendant cysts; teliospores uniformly one-celled, or those in the centre becoming two-celled by septation; outer spores adorned with simple, capitate or glochidiate processes or none; pedicel compound, composed of 2 to several strands of hyphae; spores germinating by an external four-celled promycelium bearing globular sporidia.

TYPE SPECIES: *Revenelia glandulosa* Berk & Curt. on *Tephrosia* (*Leguminoseae*) is considered as type by Arthur

DISTRIBUTION: Known in the tropical and subtropical regions of Asia, Africa and America. (170 species)

NOTES: All the species of this interesting genus are confined to hosts belonging to Euphorbiaceae and Leguminoseae. *Ravenelia atrides* was described by Sydow (1912) on *Grewia* sp. a member of the Tiliaceae collected in South Africa. This would constitute the only host outside Leguminoseae. or Euphorbiaceae. However, a collection of a rust collected in the type locality by Doidge and identified as *Revenelia atrides*, on examination by Thirumalachar (1946) proved to be species of *Dasturella*. Even the illustration given by Doidge (1926) for *R. atrides* appears to be the polar view of the telial crust of *Dasturella*. A re-study of the type of *R. atrides* is therefore necessary.

The taxonomy of the genus *Ravenelia* is a matter of opinion and general adoption. If the characters presented by the various species are strictly interpreted, the genus can be split into six or more separate genera. The pycnial character viz. subcuticular or subepidermal condition which is more constant and conservative to changes than the other spore-forms, are variable in *Raven-*

elia. The aecia may be aecidioid, caeomoid or uredinoid. The uredia and telia are subcuticular or subepidermal or intraepidermal, and the teliospores are all one-celled or some in the centre may be 2-celled.

In spite of these diverse variations, there is an underlying similarity. The telial heads with pendent hyaline cysts borne on a compound pedicel are very characteristic. The genera *Haploravenelia* and *Pleoravenelia* (=*Ravenelia* of Dietel) are based on the one-celled or two-celled characters of the teliospores. However, when species are described, they are all placed under *Ravenelia* and the one-celled or two-celled condition has been used as specific difference only. *Neoravenelia* described by Long with a single species on *Prosopis juli-flora* in United States only differs from *Haploravenelia* in possessing caeomoid aecium in contrast to aecidioid and peridiate ones present in the latter. Though taxonomically an unorthodox procedure, it seems best to preserve and adopt the procedure long established, in employing the generic name *Ravenelia* with *Haploravenelia*, *Pleoravenelia* and *Neoravenelia* as sections. The various differences in the sorus structure may be employed to separate the species.

The genera *Cystomyces* and *Spumula* are separated from *Ravenelia* on account of the presence of simple pedicels in contrast to the compound ones in the latter. *Sphaerophragmium* though possessing telial heads, lacks the characterstic cysts present in *Ravenelia*.

The following are the 3 Sections under *Ravenelia* :

(1) Teliospores 2-celled in the centre of the head ... *Pleoravenelia*

(2) Teliospores, all one-celled in the head:

(*a*) Aecia with well developed peridia ... ... *Haploravenelia*

(*b*) Aecia caeomoid ... ... *Neoravenelia*

The function of the cysts so characteristic in *Ravenelia* is not well understood so far. Unpublished work of Thirumalachar on *Revenelia hobsoni* indicates that the teliospore heads with the cysts are dispersed like urediospores following their separation from the fragile pedicels. The cysts swell in water, and gelatinise. Consequently on coming in contact with a moist surface, the telial heads get affixed to the substrate by the gelatinising and consequent drying of the cysts.

ARTHUR J. C. (1907) N. Amer. Fl. **7**: 131, 1907

..... (1934) Manual of Rusts

DIETEL, P. (1906) *Beih. Bot. Zbl.* **20**: 343-413

.... (1928) Die Natürlichen Pflanzenfamilien, **6**: 72

DOIDGE, E.M. (1926) *Bothalia*, **2**: 153

SYDOW, H. & P. (1912) *Ann. Mycol.* **10**; 438

..... (1915) Monogr. Ured. III: 224

THIRUMALACHAR, M.J. (1946) *Bull. Torrey Bot. Cl.* **73**: 346-350

(1950) Critical Notes on Rusts II. (in press)

98. SCOPELLA Mains in *Ann. Mycol. 37*, p. 58, 1939 Fig. 90

Pycnia subcuticular, applanate, with sparse ostiolar filaments. Aecia uredinoid, subepidermal, erumpent, aparaphysate; aeciospores borne on pedicels, and resembling the urediospores that follow. Uredia subepidermal, erumpent; urediospores pedicellate, with distinct germ pores. Telia subepidermal, erumpent, pale cinnamon-yellow, waxy; teliospores one-celled, pedicellate, clavate-cylindric, thin-walled, with hyaline or orange-yellow contents, germinating immediately at maturity by the prolongation of the spore apex; promycelium 4-celled and external.

TYPE SPECIES: *Scopella echinulata* (Niessl) Mains, on *Bassia latifolia* (Sapotaceae)

DISTRIBUTION: India, Ceylon, Tropical and South America (8 species)

NOTES: The genus was established by Mains for a rust on *Bassia latifolia* in India which had previously been placed under *Uromyces*. The occurence of one-celled colourless teliospores like those of *Maravalia* in association with subcuticular pycnia are important characters warranting the establishment of a separate genus. Mains stressed the importance of the fasciculate nature of the pedicels of the urediospores and teliospores, and this led other investigators to seek this as a differentiating character in establishing new genera of rusts. *Coniostelium* and *Scopellopsis*, as already pointed out, were founded more on the fasciculate nature of the pedicels of the uredia and teliospores than other diagnostic characters. Thirumalachar and Cummins (1949) have pointed out that this represents only one of the modes of spore development without any generic significance.

Scopella differs from the closely related *Maravalia* in the possession of subcuticular pycnia in contrast to the subepidermal condition of the latter. The difference between the two is the same as that between *Chrysocelis* and *Chaconia*.

Thirumalachar (1950) studied the germination in *Scopella echinulata* and found that it conformed to a type unknown among rusts. The prolongating portion of the promycelium undergoes two divisions at right angles to each other and results in the formation of four promycelial cells which are arranged in the form of a tetrahedron. Each promycelial cell rounds off and functions as sporidia. Such a type of tetrad formation is unknown in higher fungi and is reminescent of algae.

THIRUMALACHAR, M. J. & CUMMINS, G. B. (1949) *Mycologia*, **41**: *523*
THIRUMALACHAR, M. J. (1950) *Mycologia*, **42**: *(In press)*

99. SKIERKA Raciborski in *Paras. Algen u. Pilzes Javas* II, p. 30, 1900.
Syn. *Ctenoderma* Syd. H. & P. in *Ann. Mycol. 18:* 102, 1920. Fig. 91

Pycnia subepidermal, flasked shaped, with ostiolar filaments. Aecia unknown. Uredia subepidermal, deep seated, opening by a pore; urediospores pedicellate; exospore in some species protruding as lateral thickenings or ridges. Telia subepidermal, deep seated, erumpent; teliospores one-celled, sessile, hyaline, fusoid, produced in irregular succession from the base of the sorus; younger spores wedging in-between the older ones, and firmly adhering to them to produce semi-permanent or ephemeral spore-tendrils or columns; mature teliospores *two-walled* and germinating immediately at maturity.

TYPE SPECIES: *Skierka canarii* Rac. on *Canarium commune* (Burseraceae)

DISTRIBUTION: South and north-west Africa, Philippines, Java, Central America. (9 species)

NOTES: The genus is characterized by the occurrence of telia in long whitish spore tendrils which are composed of fusoid colourless spores. The spore columns are semi-permanent, and the spores can easily be separated with pressure. These telial columns are reminescent of those in *Didymopsora* where they are much shorter.

Mains (1932) made a monographic study of the genera *Skierka* and *Ctenoderma*. The genus *Ctenoderma* was founded by the Sydows who proposed four species. They mistook the thick walled urediospores for teliospores. Mains however, was able to see the real telia in the type specimens of three out of the four species of *Ctenoderma* proposed by the Sydows. They were typically those of *Skierka*. The characteristic lateral ridges or thickenings of the urediospores were found in all the species, and Mains was strongly inclined to emphasize this as a generic character of *Skierka*. In the fourth species, *Ctenoderma toddaliae*, Mains found no telia, but considering the lateral ridges of the urediospores, he suspected it to be a species of *Skierka* and deferred formal transfer. Discovery of its telia by Thirumalachar (1942) has shown that this is a species of *Didymopsora*, and that the lateral ridges of the urediospores should not be given undue importance.

The non-catenulate nature of the teliospores was pointed out by Mains, the younger spores pushing up the older ones and wedging in-between them. Such a feature is seen in *Phakopsora*, *Chardoniella*, *Kernella* and others. In

fact the semi-permanent spore column of *Skierka* can be equated with those of *Chardoniella* and *Kernella* in the type of construction.

ARTHUR, J. C. (1925)	N. Amer. Fl. **7**: 732
DIETEL, P. (1928)	Die Natürlichen pflanzenfamilien, **6**: 53
MAINS, E. B. (1939)	*Mycologia*, **31**: 175-190
SYDOW, P. & H. (1915)	*Monogr. Ured.* **III**: 330
THIRUMALACHAR, M. J. (1943)	*Proc. Indian Acad. Sci.* **16**: 165

100. SORATAEA Sydow in *Ann. Mycol.* **28**: p. 432, 1930
Syn. *Allopuccinia* Jackson in *Mycologia*, **23**: 347, 1931

Pycnia subcuticular, with sparsely developed ostiolar filaments. Aecia uredinoid and similar to the uredia that follow. Uredial initials subepidermal, sori formed above the epidermis by strands of hyphae emerging through the stoma and thus appearing superficial; surrounded by a basket of incurved, spoon-shaped paraphyses. Telia subepidermal, similar to uredia, often associated with them; teliospores 2-celled, *puccinia*-like, pedicellate, hyaline thin-walled, germinating immediately at maturity; promycelium external, four-celled, bearing globular sporidia.

TYPE SPECIES: *Sorataea amiciae* Syd. on *Amicia lobbiana* Benth. (Leguminoseae)

DISTRIBUTION: Bolivia (South America), (One species)

NOTES: The genera *Sorataea* and *Allopuccinia* were described by Sydow and Jackson respectively on *Amicia lobbiana* collected from the same locality. Thirumalachar and Cummins (1948) pointed out that the two are identical, and since the description of *Sorataea* was published nine months earlier, that name had priority and *Allopuccinia* was reduced to synonymy.

The structure of uredia and telia is similar to those of *Olivea*, *Crossopsora* and others. This along with the subcuticular nature of the pycnium separates *Sorataea* from *Puccinia*. Occasional 3-celled teliospores were found in *Sorataea amiciae* by Thirumalachar and Cummins (1948), who were inclined to consider that this character brings the genus very close to *Mimema*, a feature also pointed out by Jackson. As already discussed under *Mimema*, the differences in the structure of uredia separate the two genera.

THIRUMALACHAR. M. J. AND CUMMINS, G. B. (1948) *Mycologia* **40**: 417-422

101 SPHAEROPHRAGMIUM P. Magn. in *Ber. dtsch. bot. Ges.* **9**: p., 121, 1891 Fig. 92

Pycnia and aecia unknown. Uredia subepidermal, erumpent, with or without paraphyses; urediospores pedicellate with distinct germ-pores. Telia subepidermal, black, erumpent; teliospores pedicellate, in globose, ovate or ellipsoid heads, divided by muriform septa into 4-9 cells; cells of the teliospore reddish-brown, thick-walled, adorned with simple, capitate or glochidiate processes. Promycelium 4-celled, external.

TYPE SPECIES: *Sphaerophragmium acaciae* (Cke) Magn., on *Acacia* species (Mimosae)

DISTRIBUTION: India, South Africa, Philippines, South and Central America. (14 species)

NOTES: The genus is closely related to *Triphragmium* but differs in possessing a larger number of cells in the head (4 to 9) and in being muriform in contrast to *Triphragmium* and *Hapalophragmium*. The simple pedicels and lack of cysts separate it from *Ravenelia*, *Spumula* and *Cystomyces*.

ARTHUR, J. C.	(1925)	N. Amer. Fl. **7**: 728
DIETEL, P.	(1928)	Die natürlichen pflanzenfamilien, p. 70
SYDOW, P. & H	(1915)	Monogr. Ured. III, p. 185

102 SPHENOSPORA Dietel in *Ber. dtsch. bot. Ges., 10:* p. 63, 1892, and *Die natürlichen Pfl. Fam.*, 1 p. 70, 1897. Fig. 93

Pycnia and aecia unknown. Uredia subepidermal, erumpent; urediospores pedicellate with distinct germ pores. Telia subepidermal, erumpent, as pale yellow or whitish waxy crusts; teliospores pedicellate, colourless or subhyaline, 2-celled, the septa being vertical; thin-walled, with apical germ pores; germinating immediately at maturity; promycelium external and four celled, bearing globular sporidia.

TYPE SPECIES: *Sphenospora pallida* (Winter) Dietel, on *Dioscorea* sp. (Dioscoreaceae)

DISTRIBUTION: Central and South America (6 species)

NOTES: Only uredia and telia are known. The colourless or subhyaline and thin-walled teliospores showing two-celled condition by vertical septation are characteristic. The spores are so much unlike *Diorchidium* which is also 2-celled by vertical septation, that they cannot be confused with each other. Telio-

spores of *Diorchidium* are more of a thick-walled resting type, and the germ pores are disposed laterally, while in *Sphenospora* the teliospores germinate immediately and the germ pores are apical.

In *Sphenospora kevorkianii* parasitizing an orchid, Linder (1946) noticed that the two cells of the teliospores showed a tendency to get separated from each other half way down the apex. Basing on this character, Linder was inclined to draw some similarity between *Sphenospora* and *Ypsilopsora* described by Cummins (which was stated to have binate spores). Later studies however have indicated that *Ypsilopsora* is synonymous with *Chaconia*.

ARTHUR, J. C. (1926) N. Amer. Fl., **7**: 733
DIETEL, P. (1928) Die naturlichen Pflanzenfamilien, **6**: 68
LINDER, D. H. (1944) *Mycologia*, **36**: 464-468

103 SPUMULA Mains in *Mycologia*, *27*: p. 638, 1935. Fig. 94

Pycnia not observed. Aecia subepidermal, cupulate, erumpent and peridiate; aeciospores developed in chains. Uredia unknown. Telia subepidermal, erumpent and pulverulent; teliospores pedicellate, hemispherical, composed of 3-6 laterally connected cells, subtended by cysts which are globose or pendulous; free among themselves; pedicel simple, hyaline, attached to the fused portion of the spore-cells and free from the cysts.

TYPE SPECIES: *Spumula quadrifida* Mains on *Calliandra bijuga*. (Mimosae)

DISTRIBUTION: Mexico, Philippines and South Africa. (3 species)

NOTES: Mains in discussing the characters of the genus states that it is a simple *Ravenelia* in which no fusion of the cells has occurred. The laterally united teliospores with simple pedicels are characteristic of the genus. The number of cysts are always less than the number of cells in the teliospore, since some of the cells situated in the centre are without cysts.

The mode of attachment of the teliospore with the pedicel is the only character that separates *Spumula* from the closely related *Cystomyces* which is also a rust on Leguminoseae. The pedicels in *Spumula* are attached to the teliospore while being free from the cysts. On the other hand, in *Spumula* the pedicels are attached to the fused portion of the cysts, which in themselves are fused laterally. Whether this slight difference in attachment of the pedicel is a sufficient character to warrant the establishment of a separate genus is a matter of opinion. The life-cycles in both the genera are so little understood that it seems best to retain them as distinctly separate.

All the three species are known occur on Leguminoseae. *Spumula bottomleyae* was originally described as *Ravenelia bottomleyae* Doidge (1926) and Thirumalachar (1945) pointed out that it is a species of *Spumula*.

DOIDGE, E. M. (1926) *Bothalia*, **2**: 147
THIRUMALACHAR, M. J. (1945) *Bull. Torrey Bot. Cl.*, **73**: 346-351

104 STEREOSTRATUM P. Magn. in *Ber. dtsch. bot. Ges. 17*: p. 181, 1899. Fig. 95

Pycnia and aecia unknown. Uredia subepidermal erumpent; uredio-spores pedicellate. Telia subepidermal, forming large, flat, bright coloured, waxy crusts, sometimes up to 10 cms. in diameter; teliospores are 2-celled and *puccinia*-like, pale-yellow, with long pedicels, developed, in succession from the base of the sorus, older spores being pushed laterally by the younger ones developing in-between, closely appressed with one another, with their pedicels intertwining to form a flat expanded crust; germ pores 3-4 in each cell.

TYPE SPECIES: *Sterostratum corticioides* (Berk) Magn. on Bamboo. (Gramineae)

DISTRIBUTION: Japan (one species)

NOTES: The genus was established by Magnus to accommodate the rust forming large *Corticium*-like telial crusts. The genus has been accepted by Dietel though the Sydows consider it to be synonymous with *Puccinia*.

A morphological study of the sorus by Thirumalachar (1947) indicated charracteistic differences in the mode of teliospore formation. From the spore bed in the telia, the young pedicellate spores are produced in succession, each getting released from the basal hymenium and pushing the older ones laterally. The spores thus formed in irregular succession are compactly held together by mutual appression and intertwining of the pedicels and form flat crustose layer measuring 2-10 cms, in diameter. In the mode of spore formation *Sterostratum* resembles the other members of the 'Pucciniosirae' of Dietels's classification. It almost agrees with *Kernella* producing teliospore tendrils, with the difference that the developing teliospores are pushed laterally in *Stereostratum* resulting in a crust, while in *Kernella* they are pushed upwards to form a spore tendril.

The mode of spore development and the occurrence of 3 or 4 germ pores in each cell of the teliospore separates *Stereostratum* from *Puccinia*.

DIETEL, P. (1928) Die natürlichen Pflanzenfamilien, **6**: 66
THIRUMALACHAR, M.J. (1947) *Mycologia*, **39**: 334-340

105 TEGILLUM Mains in *Bull. Torrey Bot. Cl.*, *67*, p. 707, 1940. Fig. 96

Pycnia subcuticular, conoid. Aecia unknown. Primary uredia subcuticular bordered by paraphyses which are coalescnt at the base to form a membraneous sheet; urediospores borne singly on pedicles; secondary uredia subepidermal, erumpent, paraphysate; urediospores are similar to those of the primary sorus. Telia subcuticular; teliospores thin-walled, clavate-cylindric, colourless, sessile, germinating immediately at maturity; promycelium external and four-celled.

TYPE SPECIES *Tegillum fimbriatum* Mains on *Vitex* sp. (Verbenaceae)

DISTRIBUTION: British Honduras (one species)

NOTES: The genus was established by Mains for a rust on *Vitex* sp. collected in British Honduras, with subcuticular pycnia, primary uredia and telia but subepidermal secondary uredia. Mains pointed out that the genus differed from *Olivea* which possesses sori formed by hyphal strands emerging through the stomata. He further separated it from *Desmotelium* which showed subepidermal pycnia, uredia, and telia, though Sydow reported them to be subcuticular. A brief discussion of this has already been made under *Desmotelium*.

While *Tegilum* can be easily distinguished from *Desmotelium* and *Olivea*, its differences with *Chaconia* are less apparent. *Chaconia* possesses subcuticular pycnia and sessile one-celled, colourless teliospores which germinate immediately at maturity. The telia are however subepidermal while in *Tegillum* they are subcuticular. The uredia (secondary) of the latter genus are also subepidermal, but possess well developed paraphyses. Except for the subcuticular nature of the telia, uredia and paraphyses in uredia (secondary), *Tegillum* is almost identical with *Chaconia*. Recent studies on sorus morphology in rust fungi reval that the subcuticular or subepidermal condition is a constant feature and therefore has diagnostic value only in the case of pycnia, while in the other spore forms such a condition is subject to variation. Further studies on more species of *Chaconia* and *Tegillum* may throw more interesting light on their relationships.

106. TRACHYSPORA Fuckel. in *Bot. Ztg.* **19**, p. 250 1861. Fig. 97

Syn. *Trachysporella* Syd. in *Ann. Mycol.*, **19**: 168, 1921

Pycnia unknown. Aecia uredinoid, subepidermal and erumpent; aeciospores without apparent pedicels. Uredia unkown. Telia subepidermal, erum-

pent; teliospores 1-celled, pedicellate, globoid, cinnamon-brown; wall covered with digitate warts or tubercles; pedicel hyaline, with a distinct apical cell.

TYPE SPECIES: *Trachyspora alchemillae* Fuckel, on *Alchemilla* sp. (Rosaceae)

DISTRIBUTION: India, Java, Greenland, Europe and North America. (3 species)

NOTES: The genus includes three species. The sorus accompanying the telia has been interpreted by the early investigators and Dietel (1928) as uredia, while Arthur (1934) calls it an aecium. The systematic nature of the mycelium bearing this sorus as well as the nonpedicellate nature of the spores may be considered in designating the sorus as uredinoid aecia.

As already pointed out under *Atelocauda* the markings of the teliospores and the occurrence of apical cells in tne pedicels in *Trachyspora* are reminiscent of similar condition present in *Dicheirinia*. However, the teliospores in *Trachyspora* are one-celled in contrast to those of *Dicheirinia*: The occurrence of the apical cells in the pedicels was pointed out by Mundkur and Thirumalachar (1946) as a distinct character, separating it from *Uromyces*, with which the genus has been mistaken by several investigators including the Sydows (1910), Doidge (1926) and others,

ARTHUR, J. C. (1907) N. Amer. Fl. **7**: 177
..... (1934) Manual of Rusts, p. 97-98
DIETEL, P. (1923) *Ann. Mycol.* **21**:87-88
..... (1928) Die natürlichen Pflanzenfamilien, **6**: 57
DOIDGE, E. M. (1926) *Bothalia*, *2*: 1-228
MUNDKUR, B. B. & THIRUMALACHAR, M. J. (1946) *Mycol. Pap. No. 16*, Imperial Mycological Inst., p. 13
SYDOW, P. & H. (1910) Monogr. Ured. II p. 196

107 TRANZSCHELIA Arth. in *Result. Sci. Congr. Internat. Bot. Wien*, 1905, p. 340, 1906

Syn. *Lipospora* Arth. in *Bull. Torrey Bot. Cl.*, **48**: 24, 1921

Polythelis Arth. in *Result. Sci. Congr. Internat. Bot. Wien*, 1905, p. 341, 1906

Pycnia subcuticular, hemispheric, conoid. Aecia subepidermal, erumpent, peridiate; aeciospores catenulate, angularly globoid. Uredia subepidermal, erumpent, usually paraphysate; urediospores pedicellate with distinct germ-pores.

Telia subepidermal, erumpent; teliospores pedicellate, 2-celled and *puccinia*-like, deeply coloured and resting; cells usually fragile and separable, with a single germpore in each cell.

TYPE SPECIES: *Tranzschelia cohaesa* (Long) Arthur on *Anemone decapetata*. (Ranunculaceae)

DISTRIBUTION: Widespread. (6 species)

NOTES: The genus includes species which have been recorded so far on *Prunus* and on family Ranunculaceae. In describing the genus Arthur (1934) stressed the occurrence of sporogenous basal cells manifesting a union of pedicels at the base. He considered this to be a character allied to *Ravenelia*. However, recent studies have indicated that the sporogenous basal cells in themselves have no generic significance. Arthur further states that the genus can be separated from *Puccinia* by the absence of a common membrane enclosing two cells of the teliospore. This character is often duplicated in some species of *Puccinia* and it is doubtful if much reliance can be laid on this as a differentiating character.

The subcuticular nature of the pycnia is an important character separating it from *Puccinia*. Subcuticular pycnia are also present in *Uropyxis*, *Prospodium* and *Leucotelium*. The first two genera can be separated from *Tranzschelia* on other characters, but it is difficult to differentiate it from *Leucotelium*. The latter genus resembles *Tranzschelia* in all respects except that its teliospores are colourless in contrast to the more opaque and coloured ones in *Tranzschelia*.

ARTHUR, J. C.	(1917)	N. Amer. Fl., **7**: 151
ARTHUR, J. C.	(1934)	Manual of Rusts, p. 71
DIETEL, P.	(1922)	*Ann. Mycol.*, **20**: 30-31
....	(1928)	Die natürlichen Pflanzenfamilien, **6**: 57
SYDOW, P. & H.	(1915)	Monogr. Ured., III, 2
TRANZSCHEL, P.	(1917)	*Trav. de. Mus. Bot. St. Petersburg*, II, p. 67
.....	(1935)	*Riv Patol. Veg.*, **25**: 183

108. TRICHOPSORA Lagerh. in *Ber. dtsch, bot. Ges.*, **9**, p. 347, 1891. Fig. 98

Pycnia subepidermal, flask-shaped. Aecia and uredia unknown. Telia subepidermal, deeply sunk in the host, developing in irregular succession from the base, one-celled, spindle-shaped; teliospores emerging out in long *Cronartium*-like spore tendrils; teliospores held together by gelatinous matrix; horny when dry; mature teliospores spindle-shaped, thin-walled, fusoid at both ends, associated with sterile cells (undeveloped spores), and germinat-

ing at maturity by a 4-celled internal promycelium, bearing small sporidia or sterigmata.

TYPE SPECIES: *Trichopsora tournefortiae* Lagerh. on *Tournefortia* sp. (Boraginaceae)

DISTRIBUTION: Ecuador (One species)

NOTES: *Trichopsora* is an interesting monotypic genus developing long *Cronartium*-like spore-tendrils. In the shape of the teliospores and mode of spore formation, there is some resemblance with *Skierka* which also has spindle-shaped teliospores developed in irregular succession and producing spore columns. But the telial columns of *Trichopsora* are more firm due to the binding gelatinous layer as against the semi-permanent nature in *Skierka* where the spores are held by mere lateral adpression with each other. The internal promycelium in *Trichopsora* is a distinct character separating it from the other members of the '*Pucciniosirae*' of Dietel's classification.

(1) DIETEL, P. (1928) Die natürlichen Pflanzenfamilien, **6**: 94
(2) SYDOW, P. & H. (1915) Monogr. Ured. III, 671-671

109. TRIPHRAGMIOPSIS Naumov in *Bull. Soc. Mycol. France*, **30**, p. 15, 1914

Syn. *Nyssopsorella* Syd. *Ann. Mycol* **19**: 169, 1921

Pycnia not known. Aecia subepidermal, cupulate and peridiate: aeciospores produced in chains. Uredia unknown. Telia subepidermal erumpent; teliospores pedicellate, *Triphragmium*-like, chestnutbrown, with two germ pores in each cell; epispore covered with dense warts.

TYPE SPECIES: *Triphragmiopsis jeffersoniae* Naum. on *Jeffersonia dubia*. (Berberidaceae)

DISTRIBUTION: Eastern Russia and Southern Europe (2 species)

NOTES: Tranzschel (1925) separated *Triphragmium* as previously understood, into two sections; *Triphragmium* Link with a single germ pore in each cell, and the second section having two germ pores in each cell of the teliospore. In the latter section, those forms with light-brown teliospores were placed under *Triphragmiopsis* and the group with nearly opaque teliospores under *Nyssopsora* Arthur. It is therefore manifest that *Triphragmiopsis* and *Nyssopsora* while differing from *Triphragmium* in the number of germ pores, are in themselves separated

form each other by the deeper shade of *Nyssopsora* teliospores. Pycnia being unknown in both the genera, their discovery may afford a better basis for separating them than the slender differentiating characters employed at persent.

ARTHUR, J C. (1934) Manual of Rusts, etc., p. 99
DIETEL, P. (1928) Die natürlichen Pflanzenfamilien, **6**: 69
TRANZSCHEL, W. (1925) *J. Soc. Bot. Russie*, **8**: 123-32

110. TRIPHRAGMIUM Link in *Spec. Pl.* II, p, 84, 1824. Fig. 99

Pycnia subcuticular, conoid, without conspicuous ostiolar paraphyses. Aecia (primary uredia) uredinoid, subepidermal, erumpent and without paraphyses. Uredia (secondary) subepidermal, erumpent, with peripheral paraphyses. Telia subepidermal, rupturing through the epidermis; teliospores pedicellate, triquetrously three-celled, the odd cell being basal and attached to the pedicel; walls coloured, more or less verruculose, with an apical germ pore in each cell.

TYPE SPECIES: *Triphragmium ulmariae* (DC) Link on *Fillipendula ulmaria* (Rosaceae)

DISTRIBUTION: Europe, Siberia, Japan, U. S. A. (4 species)

NOTES: The basis for separating *Triphragmium* from *Triphragmiopsis* and *Nyssopsora* has already been pointed out. *Hapalophragmium* differs from *Triphragmium* in that the odd cell is terminal and not basal. But for this single differentiating character, the two resemble each other in all respects. The finding of subcuticular pycnia, and subepidermal, uredinoid aecia and subepidermal paraphysate uredia recently noticed for *Hapalophragmium mysorense* by Thirumalachar (1950) has brought the two genera very close together.

ARTHUR, J. C. (1934) Manual of Rusts, 98-99
DIETEL, P. (1928) Die natürlichen Pflanzenfamilien, **6**: 64
SYDOW. P. & H (1915) Monogr. Ured. III, p. 171
TRANZSCHEL, W. (1925) *J. Soc. Bot. Russie* : 8123-132
THIRUMALACHAR, M. J. (1951) *Mycologia* (in press)

111. TROCHODIUM Sydow in *Ann. Mycol* **17**, p. 106, 1919. Fig. 100

Pycnia subepidermal, flask shaped, ostiolate, with conspicuous ostiolar paraphyses. Aecia subepidermal, erumpent, cupulate, and peridiate, with aeciospores developing in chains. Uredia subepidermal, urediospores borne on

pedicels. Telia subepidermal, erumpent, dark chestnut-brown to black; teliospores pedicellate, one-celled, chestnut-brown, with a ring-like thickening at the apex bordering the single apical germ pore and with the exospore traversed by longitudinal ridges which converge at the base. Pedicel hyaline, swelling considerably in water into a balloon shaped body at the region below the spore attachment. Spores germinating by a four-celled promycelium bearing globular sporidia.

TYPE SPECIES: *Trochodium ipomoeae* (Thuem.) Syd. on *Ipomoea argyreoides*. (Convolvulaceae)

DISTRIBUTION: India, South Africa. (3 species)

NOTES: The genus was established by Sydow to accommodate the rust on *Ipomoea* in South Africa which had previously been assigned to *Uromyces*. The occurrence of longitudinal ridges on the exospore and hygroscopic pedicels which get inflated considerably were taken as the main distinguishing characters. The genus has been recognised by Dietel (1928), Clements & Shear (1931) and others, though Doidge (1926) considers it to be synonymous with *Uromyces*.

Pycnia were observed for the genus by Thirumalachar (1942) in *Trochodium sampathense* and these are similar to those found in *Uromyces*. Consequently, the genus is separated from *Uromyces* only on the teliospore characters. The longitudinal ridges on the exospore of the teliospores, when carefully examined, show secondary striae, thus giving a false reticulate appearance to the exospore. But the primary ridges traverse only longitudinally. The apical germ pore is situated in a depression and is bordered by a thickened ridge. The highly hygroscopic and inflating nature of the pedicel is characterstic and this may have some function connected with the spore dispersal similar to the cysts of *Ravenelia* (Thirumalachar 1950).

DIETEL, P.	(1928)	Die natürlichen Pflanzenfamilien, **6**: 81
DOIDGE, E. M.	(1926)	*Bothalia*. **2**: 13
THIRUMALACHAR, M. J.	(1942)	*J. Indian Bot. Soc.*, **21**: 59-68
....	(1951)	(In press)

112. URAECIUM Arthur in *Bull. Torrey Bot. Cl.*, **60**, p. 476, 1933

Uredo ?

Pycnia subcuticular or subepidermal, with or without paraphyses. Aecia uredinoid, with or without paraphyses. Aeciospores borne singly on pedicels, 1-celled, ovate-ellipsoid or globular with echinulate wall.

TYPE SPECIES: *Uraecium holwayi* Arthur on *Tsuga heterophylla* (Coniferae)

NOTES: This form-genus was founded by Arthur to accommodate uredinoid aecial stages of rusts on gymnospermous and angiospermous hosts whose telial connections are not known. The genus is stated to have a status as other form-genera such a *Uredo*, *Caeoma*, *Aecidium*, ect. In several brachy-forms of rusts the pycnia accompany the primary uredia. The secondary uredia are usually associated with telia. The form-genus *Uraecium* differs from *Uredo* only in that the pycnia are associated with the former. Even though it is given the status of aecia (uredinoid aecia) on account of its sequence in development, it is structurally indistinguishable from *Uredo*. On the other hand the other form-genera, *Aecidium*, *Caeoma*, *Uredo*, and *Peridermium* are separated on the basis of distinct morphological variations.If the various species of *Uredo* are re-examined, several of them would be found to be associated with pycnia, so that they should be transferred from one imperfect form-genus to another, though there are no morphological differences. The maintenance of form-genus *Uraecium* therefore seems to us superfluous since it is not based on any structural difference. For instance, repeating secondary aecia of rusts (in the absence of any telial stage being known) are placed under *Aecidium*, though they are not accompanied by pycnia. Even so, the well established form-genus *Uredo* can include imperfect rust species whose uredial stages are either found alone or accompanied by pycnia

ARTHUR, J. C. (1934) Manual of Rusts, etc., p. 391

113. UREDINOPSIS Magnus in *Atti. Congr. Bot. Genova*, p. 167, 1893.

Pycnia subcuticular, conoid. Aecia subepidermal, white, cylindric, ruptured at the apex with delicate peridia; aeciospores broadly ellipsoid, verrucose, with colourless cell contents. Uredia subepidermal, bullate, with a delicate inconspicuous peridium, usually developing beneath stomata of the host; urediospores of varying forms; hyaline narrowly fusiform to ovoid-fusiform with a slender beak, usually extruded out in white vermiform threads; germ pores indistinct, mostly smooth or laterally ridged; amphispores when present, angularly obovate, verrucose, and without the beak. Telia subepidermal, composed of teliosporesin the in ter-cellularspaces beneath the epidermis, aggregated or scattered at random; teliospores globoid to ellipsoid; hyaline contents, usually 4-celled; wall colourless, thin.

TYPE SPECIES: *Uredinopsis filicina* (Niessl) Magn. on *Phegopteris vulgaris.* (Polypodiaceae)

DISTRIBUTION: Europe, North and South America, Japan and eastern Asia. (25 species)

NOTES: The genus is heteroecious, and so far as known has aecial stage on fir, *Abies* and uredia and telia on various ferns. The genus has been monographed by Faull (1938) who gives a detailed taxonomic account and geographical distribution.

Niessl first established the fungus as *Protomyces filicinus*, which was later considered by Winter as *Uredo*. However, Magnus established *Uredinopsis* as a genus of Phycomycete, but it was Dietel (1895) who pointed out that it was a rust genus.

Uredinopsis is considered to be the most primitive among the living rust fungi, because of their host restriction on ferns and gymnosperms, lack of pigmentation in any spore-forms, and the absence of a sorus, in the usual sense, for the telia.

Detailed cultural studies have been carried out by Kamei in Japan and Faull in U.S.A. The aecial stage is always on *Abies*, while the telia occur on several fern genera of the Polypodiaceae and *Osmunda* of the Osmundaeae. The specific differentiation is based mostly on the uredial stage, with the two types of urediospores. The beaked teliospores, often possessing lateral ridges and extruded out of the sorus in long cirri or columns superficially resembles the telium of *Skierka*. The presence or the absence of amphispores and the type of the pedicel cells offer the basis for separating the species.

There are no telia in the true sense of the word, since no sorus is formed. The teliospores lie scattered or are occasionally aggregated beneath the epidermis into a diffuse layer. Bell (1924) and Pady (1933) have shown that the teliospores are strictly subepidermal and intercellular in origin.

ARTHUR, J. C.	(1917)	N. Amer. Fl., **7**: 115
.....	(1934)	Manual of Rusts, p. 2
BELL, H. P.	(1924)	*Bot. Gaz.*, **77**: 1-31
DIETEL, P,	(1895)	*Ber. dtsch. bot. Ges.* **8**: 326-332
.....	(1928)	Die natürlichen Pflanzenfamilien, **6**: p. 36
FAULL, J. H.	(1938)	*Contrib. Arnold. Arb*, **11**: 1-120
HIRATSUKA, N.	(1936)	*Mem. Tottori Agric. Coll.* **4**: 1-374
KAMEI, S.	(1930)	*Ann. Phytopath. Soc. Japan* **2**:207-228
.....	(1933)	*J. Soc. Agric. For. Sapporo*, **24**: 364-365
PADY, S. M.	(1933)	*Canad. J. Res.*, **9**: 458-485
SYDOW, P. & H.	(1915)	Monogr. Ured. III, 482-484

114. UREDO Persoon in *N. Mag. Bot.*, I, p. 93, 1794
Syn. *Trichobasis* Lêv. in *Ord. Dict. Hist Nat.* **1**, p. 685, 1848

Uredia subepidermal, with or without peridium or paraphyses; uredio-spores 1-celled, borne singly on pedicels, coloured or hyaline; epispore variously sculptured; germ-pores obscure or distinct.

TYPE SPECIES: *Uredo helioscopiae* Pers. on *Euphorbia heliosçopia.* (Euphorbiaceae)

NOTES: This form-genus, includes rust species whose telial and aecial stages are not known. Some of the genera like *Hemileia* are identified chiefly by the urediəl stage. Peridiate uredia are characterstic of several genera of the Melampsoraceae. As stated before, the fern rust genus *Calidion* Syd. and *Uraecium* Arthur should more properly be merged with *Uredo.*

ARTHUR, J. C. (1907) N. Amer. Fl. **7**: p. 97 and p. 605
DIETEL, P. (1928) Die Natürlichen Pflanzenfamilien, **6**: 98
SYDOW, P. & H (1924) Monogr. Ured. IV,

115. UROMYCES Link in *Mag. Ges. Naturf. Freunde, Berlin,* **8**: *p. 28, 1816* (Fig. 102)

Syn. *Alveomyces* Bubak in *Ann. Natur. (Mus.) Hofmus, Wien,* **28**, p. 190, 1914

Caeomurus S. F. Gray, *Nat. Arr. Brit.* pl. 1, p. 541, I821
Capitularia Rabenh., *Bot. Ztg.* **9**: 499, 1851
Dichlamys H. & P. *Ann. Mycol.* **17**: 105, 1920
Groveola Syd. *Ann. Mycol.* **19**: 173, 1921
Haplotelium Syd. *Ann. Mycol.* **20**: 124, 1922
Klebahnia Arth. *Result Sci. Congr. Internat. Bot. Wien*, 1905, p. 345, 1906
Nielsenia Syd. *Ann. Mycol.* **19**: 171, 1921
Nigredo Roussel, *Fl. Calvados*, p., 47 1806
Ontotelium Syd. *Ann. Mycol.* **19**: 174, 1921
Pucciniella Fuckel *Symb. Mycol.*, p. 60 1869
Schroeteriaster Magnus, *Ber. Dtsch Bot. Ges.*, **13** : 334, 1895
Pucciniola Marchand, *Bijdr. Nat. Wet.* **4**: 47. 1829
Teleutospora Arth. *Bull. Torry Bot. Cl.* **48**: 38, 1921
Telospora Arth. *Result Sci. Congr. Internat. Bot. Wien*, 1905, p. 346, 1906

Uromycodes Clements in Genera of Fungi, p. 98, 1909
Uromycopsis (Schroeter) Arth. *Result Sc. Congr. Internat. Bot. Wien*, 1905 p. 345, 1906

Pycnia subepidermal, flask-shaped, with ostiolar paraphyses. Aecia subepidermal, cupulate, erumpent, peridiate; aeciospores developed in chains; epispore smooth or variously sculptured. Uredia subepidermal, with or without paraphyses; urediospores borne singly on pedicels with distinct or indistinct germ pores. Telia subepidermal, erumpent or non-erumpent, compactly grouped; teliospores 1-celled, pedicellate, ovate-ellipsoid or obconical; wall thick, coloured pale yellow to reddish-brown, with an apical germ pore, often hygroscopic, swelling considerably.

TYPE SPECIES : *Uromyces appendiculatus* (Pers.) Link (Leguminosae)

DISTRIBUTION: World-wide. (Over 600 species)

NOTES: The genus differs from *Puccinia* in being one-celled. As already stated under *Puccinia*, the mesospores of the latter may be mistaken for *Uromyces*. As understood at present, teliospores of *Uromyces* are thick-walled, and subhyaline or coloured. But there is intergrading of characters with thin-walled forms, so that the separation of the genera like *Poliotelium* becomes arbitrary. Species of the genera *Scopella*, *Maravalia*, *Trochodium* and other were orginally placed under *Uromyces* before their differentiating characters were understood. *Scopella*, *Marvalia* and some other genera do not possess apical germ pores, but their promycelium is the prolongation of the teliospore apex. The genus *Haplopyxis*, though having one-celled *Uromyces*-like teliospores, has three layered walls and two lateral germ-pores like those of *Uropyxis*.

The genus *Dichlamys* Syd. was founded by Sydow (1919) for *Uromyces*-like species possessing hygroscopic exospore layer in the teliospore. Thirmalachar (1950) pointed out that it is only a specific difference and should not be used to separate genera. Species in several other genera like *Puccina alli-cepulae*, *Uropyxis amorphae* and others possess exospores which swell in water up to 15μ, so that this character is of specific significance only. Thirumalachar therefore merged *Dichlamys* with *Uromyces*.

The genus *Schroeteriaster* was founded by Magnus (1896) on *Rumex alpinus* with uredia and telia. The telia were stated to be in non-erumpent lencicular crusts somewhat similar to *Phakopsora*. The genus has been recognised by the Sydows, Dietel and others. However, Mains (1934) who studied the type found that each teliospore was subtended by basal cell or

pedicel and hence merged *Schroeteriaster* as a synonym ot *Uromyces*. However, since pycnia and aecia were unknown, for the genus, their discovery was neccssary before accepting this transfer proposed by Mains.

The pycnial and aecial stages were discovered by Gaümann (1947). The aecial stage of *Schroeteriaster alpnius*, the type of the genus, was found on *Ranunculus montanus*, the pycnia being subepidermal, and the aecia cupulate and peridiate. Gaümann rightly remarks that it is a member of the Pucciniaceae, for had it been a member of the Melampsoraceae, the aecial stage would have occurred on *Larix* and other conifers. It therefore seems proper to consider *Schroeteriaster* as a synonym of *Uromyces*.

ARTHUR, J. C.	(1922)	N. Amer. Fl. **7**: 587
DIETEL, P.	(1928)	Die natürlichen Pflanzenfamilien, **6**: p. 80
DOIDGE, E. M.	(1926)	*Bothalia*, **2**: 1-228
GAÜMANN, E.	(1947)	*Ber. Schweiz. Bot. Ges.* **57**: 256-257
MAINS, E. B.	(1934)	*Ann. Mycol.* **32**: 256
MAGNUS, P.	(1896)	Ber. Dtsch. Bot. Ges. **14**: 130
SYDOW, H. & P.	(1904)	Monogr. Ured. II,
.....	(1920)	*Ann. Mycol.* **17**: 105
THIRUMALACHAR, M.J.	(1950)	(in press)

116. UROMYCLADIUM McAlpine in *Ann. Mycol.* **3**, p. 321,1905 (Fig. 103)

Syn. *McAlpinia* Arth. *Result. Sci. Congr. Internat. Bot. Wien*, p. 340, 1906

Pycnia subcuticular, hemispheric, without conspicuous ostiolar paraphyses. Aecia unknown. Uredia subepidermal, erumpent; urediospores pedicellate. ellipsoid to fusiform with equatorial germ pores. Telia subepidermal, erumpent; teliospores one-celled, globose to depressed-globose, borne at the apices of bi-or trifurcated simple pedicel, chestnut-brown, warty or striated with an apical germ pore; spores borne in cluster on a single pedicel either all fertile or some sterile and appearing as vesicles or cysts.

TYPE SPECIES: *Uromycladium simplex* McAlp. on *Acacia* sp. (Mimosae)

DISTRIBUTION: Australia, Java. (7 species)

NOTES: All the species so far known occur on species of *Acacia* and *Albizzia*, some of them producing conspicuous galls. The genus is stated to be intermediate between *Uromyces* and *Ravenelia* on account of the so-called cysts present in some species. But actually they are not comparable to the cysts of *Ravenelia* where they are produced from the spore initial itself. In *Uromycladium* the cyst represents a sterile spore and in fact takes the place of an otherwise

fertile spore. While there is no relationship with *Ravenelia*, its resemblance with *Diabole* is quite close. In the latter genus however, the apical cells of the main pedicels are distinct, and there are no steriles pores associated in the cluster.

CUNNINGHEM, G. H. (1931) Rusts of New Zealand, p. 205
DIETEL, P. (1928) Die naturlichen Pflanzenfamilien, **6**: 67
SYDOW, P. & H. (1915) Monogr. Ured. III, p. 335

117. UROPYXIS Schroeter in *Hedwigia*, **14**: p. 165, 1875 (Fig. 104)
Syn. *Collispora* Arth. *Bot. Gaz.* **39**: 390, 1905

Pycnia subcuticular, conoid, with ostiolar filaments. Uredia subepidermal, erumpent, usually paraphysate; urediospores pedicellate, ovate-ellipsoid with distinct germ pores. Telia subepidermal, often paraphysate; teliospores two-celled and *Puccinia*-like, wall layer laminate, inner firm and coloured, outer hyaline and hygroscopic; germ pores two in each cell and laterally disposed.

TYPE SPECIES: *Uropyxis amorphae* on *Amorpha herbacea* Walt. (Bignoniaceae)

DISTRIBUTION: North and South America. (24 species)

NOTES: The genus closely resembles *Puccinia* and in fact several species of *Uropyxis* were previously placed under *Puccinia*. The occurrence of subcuticular pycnia and two laterally disposed germ-pores in the teliospores separates *Uropyxis* from *Puccinia*. *Haplopyxis* and *Phragmopyxis* are differentiated from *Uropyxis* in that they possess one-celled teliospores respectively, while in other essential features they resemble *Uropyxis*. The genus *Cumminsiella* has *Uropyxis* -like 2-celled teliospores, but the pycnia are subepidermal in contrast to the subcuticular ones in *Uropyxis*.

ARTHUR, J. C. (1907) N. Amer. Fl. 7. 154
..... (1934) Manual of Rusts p. 76
DIETEL, P. (1928) Die natürlichen Pflanzenfamiline. *6*: 65

118. XENODOCHUS Schlecht in *Linnaea*, I, p. 237, 1826 (Fig. 105)

Syn. *Phragmidiopsis* Winter in Rebenhorst *Krypt. Flora*, *1*, p. 227, 1882

Pycnia subcuticular, conoid, without conspicuous ostiolar paraphyses. Aecia caeomoid, without peridia or paraphyses; aeciospores globoid-ellipsoid, developed in chains. Uredia unknown. Telia subepidermal, erumpent and

soon becoming naked, black; teliospores pedicellate, 3 to many-celled phragmospores, cells monili form appearing like string of beads, reddish-brown; germ-pores single in the apical cell, and 2, opposite, laterally disposed, beneath the septum, in the other cells.

TYPE SPECIES: *Xenodochus carbonarius* Schlecht on *Sanguiserba officinalis* (Rosaceae)

DISTRIBUTION: Europe, North America and Japan. (2 species)

NOTES: The genus is closely related to *Phragmidium*, with which it is made a synonym by the Sydows and Ed. Fischer. Its occurrence on rosaceous hosts, with subcuticular pycnia, caemoid aecia and phragmosporic teliospores all point out close relationship with *Phragmidium*. The only basis for separation is the disposition of the germ pores, which is one in the upper cell, and two lateral ones in the rest, which are situated beneath the septum and not equatorial. The pedicels do not swell in water, and in this respect it resembles *Frommea* which however has a single germ.pore in all the cells of the teliospore. *Xenodochus* is recognised as a distinct genus by Arthur, Dietel and others.

ARTHUR, J. C.	(1907)	N. Amer. Fl. 7: 182
.....	(1934)	Manual of Rusts, 91-92
DIETEL, P	(1928)	Die natürlichen Pflanzenfamilien, 6: 63
SYDOW, P. & H.	(1915)	Monogr Ured. III, p 156-158

119. XENOSTELE Sydow in *Ann. Mycol.* xviii, p. 178, 1921

Pycnia, aecia and uredia unknown. Telia subepidermal, erumpent, developed usually on gall-like outgrowths of the host; peridiate; peridium well developed, composed of rectangular to polygonal cells; teliospores pedicellate, 2-celled, *Puccinia*-like, cells sometimes fragile and easily separating; germ pores single in each cell; spores germinating by a four-celled promycelium bearing globular basidiospores.

TYPE SPECIES: *Xenostele echinacea* (Berk.) Sydow on *Actinodaphne molochina* (Lauraceae)

DISTRIBUTION: India, Ceylon, Japan and China (4 species)

NOTES: All the species so far known occur on Lauraceous hosts. Earlier literature indicates that the telia were mistaken for aecia on account of the occurrence of incurved peridia, and fragile teliospores separating into one-celled spores. In fact, Berkeley (1854) named the species on *Actinodaphne* as *Aecidium echinaceum*.

Only the telial stage is known, and the discovery of other spore forms is necessary before the genus can be stabilised. At present it is separated from *Puccinia* on account of the presence of peridial layer bordering the telia. Recent studies point out that *Xenostele* may be synonymous with *Puccinia* on account of the following facts:

(a) Cummins (1949) studied several species of *Puccinia* on Lauraceae from China. In *Puccinia cinnamomicola*, Cummins noticed the occurrence of sterile aecia composed of compacted cells which are apparently non-functional, associated with telia. In both *Xenostele echinacea* and *X.litseae* the telia develop beneath this peridium and hence the occurrence of over-arching peridium. Cummins also noticed telia developing separately and not associated with peridium in P. *cinnamomicola*, and this feature casts doubt on the validity of the genus *Xenostele*. Thirumalachar also reported the occurrence of peridial layer in *Xenostele indica* on *Neolitsea zeylanica* in India. In a recent collection studied by him, the telia in several cases were without the accompanying peridial layer.

Thirumalachar (1950) noted that in *Uromyces hobsoni* on *Jasminum grandiflorum*, the telia always develop within old aecial cups. Consequeutly the peridial layer of the aecium which is persistent, later surrounds the telia also. Under certain unfavourable circumstances, there is short-cycling and telia develop from young aecia. In such cases, the unopened telia were seen covered by the inarching peridia. On a casual examination, these telia would appear to be peridiate.

After considering these facts, Thirumalachar (1950) was inclined to consider that the peridium in the telia of *Xenostele* may have had similar origin. Further studies alone would lend support or modify the assumpiton.

BERKELEY, M. J. (1854) *Hooker's J. Bot* **6**: 231
CUMMINS, G. B. (1948) *Bull. Torrey Bot Cl* **76**: 31-38
TIRHUMALACHAR, M. J (1950) Critical Notes on Rusts (in Press)

120. ZAGHOUANIA Patouillard in *Bull. Soc. Mycol. France*, xvii, p. 187, 1901 (Fig. 106)

Pycnia subepidermal, flask-shaped, with ostiolar paraphyses. Aecia subepidermal, cupulate, erumpent; aeciospores developed in catenations. Uredia subepidermal, urediospores pedicellate, with several germ pores. Telia erumpent, often developing within old uredia; teliospores pedicellate, one-celled,

warty; wall thin and colourless; teliospores germinating at maturity intrasorum; promycelium semi-internal, emerging by the side of the pedicel and bearing globular sporidia.

TYPE SPECIES: *Zaghouania phillyreae* Pat. on *Phillyrea media* (Oleaceae)
DISTRIBUTION: Tunis, Mediterranean regions (One species)

NOTES: This genus shows remarkable similarity to *Cystopsora*, also occuring on the Oleaceae. This close resemblance was pointed out by Butler (1910), and Dietel (1928) rightly includes both of them under the tribe 'Zaghouanieae'.

Pycnia, aecia and shape and type of germination of the teliospores are similar in both the genera. Germination is by semi-internal 4-celled promycelium in both the genera and under certain conditions producing only 2-celled promycelia. This feature has already been discussed under *Cystopsora*. The important difference between the two genera lies in the structure of the telia. In *Cystopsora* they are superstomal, the sporophores bearing clusters of teliopores and thus resembling the sorus of *Hemileia*. On the other hand the telia of *Zaghouania* are subepidermal, the telia being exposed by the rupture of the epidermis.

BUTLER, E J.	(1910)	*Ann. Mycol. 8.* 448
DIETEL, P.	(1928)	Die naturlichen Pflanzenfamilien *6*: 53
SYDOW, P. & H.	(1915)	Monogr. Ured. III, 586-589
THIRUMALACHAR, M. J.	(1945)	*Bot. Gaz. 107:* 74-861

FOSSIL RUST GENERA

A. AECIDITES Debey & Ettinghausen in *Denkschr. Akad. Wiss. Wien*, xvi, p. 212, 1854

Four species described as producing cupulate structures on leaves, type species being *Aecidites stellatus*. No spores have been observed. Dietel (1928) gives Persoon as authority.

B. PHELONITIS Fresen. (cited from Dietel, 1928)

Pseudoperidia round to elongate, irregular to polygonal, brown, with smooth, hexagonal, areolate aeciospores. Type is *Phelonitis lignitum* Fres. within the seed fragment of *Glyptostrobus*.

C. PUCCINITES Ettinghausen, 1855

Spores not observed but known to produce elongate streaks on monocot leaves. Dietel (1928) gives Persoon as authority.

D. TELEUTOSPORITES Ren.

Dubiously referred to as representing a fossil rust genus. Described as occurring within the macrospores of the fossil fern *Lepidodendron*, with a stalk and *Puccinia*-like spores.

DOUBTFUL OR EXCLUDED GENERA

E. AECIDIOCONIUM Vuillemin, in *Compt. Rend. Acad. Sci. Paris*, CXV, 966, 1892

Monotypic genus with *Aec. barteti* Vuillem. on *Pinus montana* as type. Dietel (1928) considers that it is probably not a rust.

DIETEL, P. (1928) Die naturlichen Pflanzenfamilien 6: 98

F. AECIDIOLUM Unger; A name at one time and sometimes given to the pycnial stage of rusts (Ainsworth & Bisby, 1945)

G. KWEILINGIA Teng in *Sinensia*, xi, p. 124, 1940

This was first described by Teng (*Sinensia*, ix, p. 226, 1938) as *Chrysomyxa bambusae* and later made the type of his new rust genus *Kweilingia*. Only telia were described as follows: "Telia subepidermal soon erumpent, confluent and crustose, waxy, dark-brown. Teliospores catenulate with the chain laterally united, 1-celled, oblong, cuboid with smooth brownish walls; germinating typically by a 4-celled promycelium bearing globose or subglobose sporidia". Thirumalachar (1950) who re-examined the type material found that the fungus was not a rust but possibly a member of the Auriculariaceae.

Thirumalachar, M. J. 1950 (in press)

H. PERICLADIUM Passerini in *Nuovo G. Bot. Ital.* vii, p. 185, 1875

The genus was founded by Passerini as a rust, for a gall producing fungus on *Grewia* sp. Later the genus was merged into *Ustilago* but recent studies by Mundkur (1944) have shown that *Pericladium* is a distinct genus of smuts.

MUNKUR, B.B. (1944). *Mycologia, 36: 292*

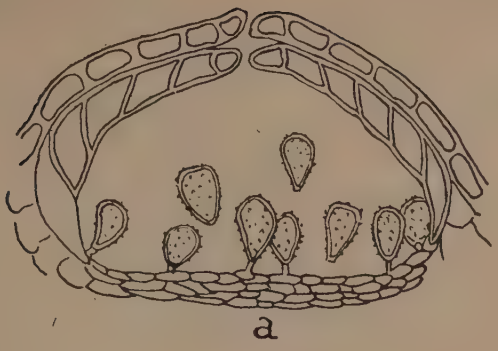
I. SARCORHOPALUM Rabenhorst

The genus was based on a collection of a fungus on a fern, *Aspidium*, made in the Nilgiris, India. The telia were described as producing long *Cronartium*-like spore-horns. The fungus Rabenhorst was referring to was undoubtedly a species of *Taphrina* (*Taphrina cornu-cerevii*) on *Aspidium* which induces the

formation of large antler-like outgrowths on the fronds. Abundant material has been studied from material collected in the Nilgiris which is the type locality.

J. ULEIELLA Schroeter in *Hedwigia*, Beiblatt 33, p. 65. 1894

The genus was established to accomodate a fungus on shoots of *Araucaria imbricata* in Brazil with *Uleiella paradoxa* Schroeter as the type. Later Dietel and Niger (1899) added another species, *Uleiella chilensis*, on the same host genus. The fungus forms black sooty spore-masses at the end of hyphae. Dietel (1897-1900) himself considered the fungus as a doubtful member of the Hemibasidii. Recent study of athentic specimens of both the species of *Uleiella* by Thirumalachar (1949) has revealed that the spores are borne at the ends of branching hyphae and the so-called 'sporidia' of Schroeter are endospores. The fungus is neither a smut nor a rust.



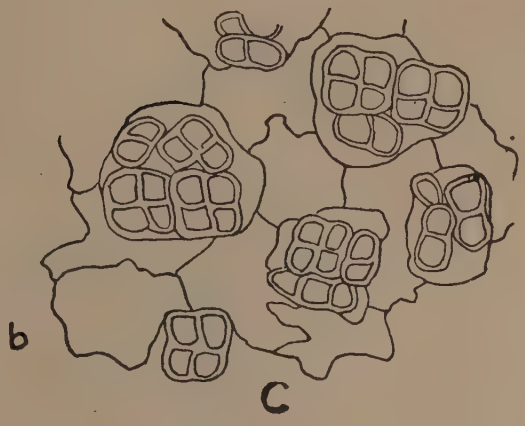


Fig. 84 Prospodium Fig. 85 Puccinia Fig. 86 Pucciniastrum

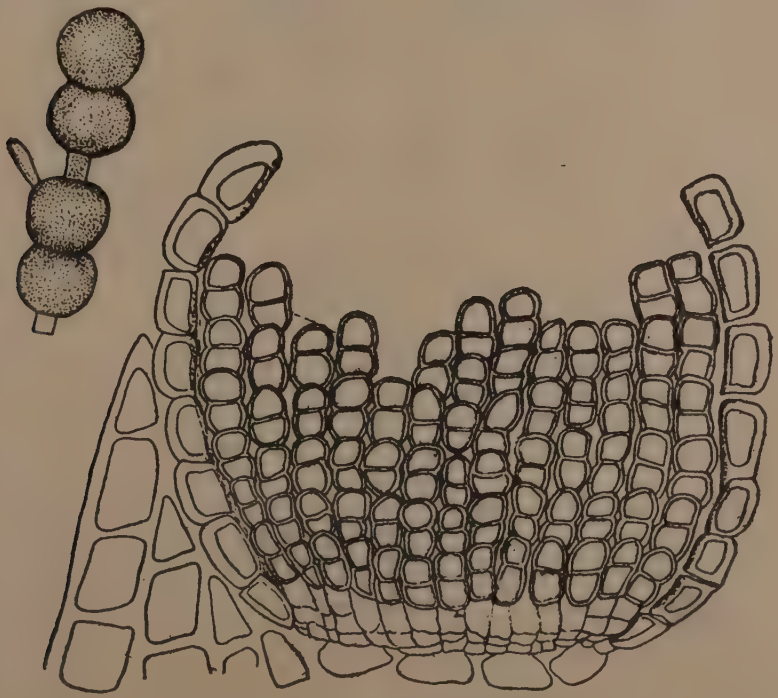


Fig. 87 Pucciniosira

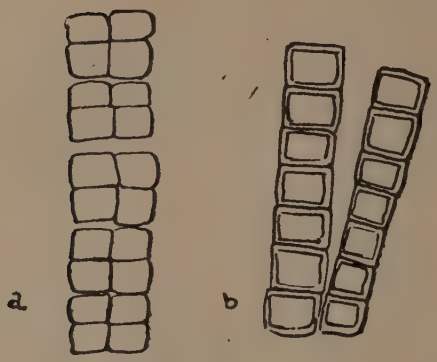


Fig. 88. Pucciniostele.

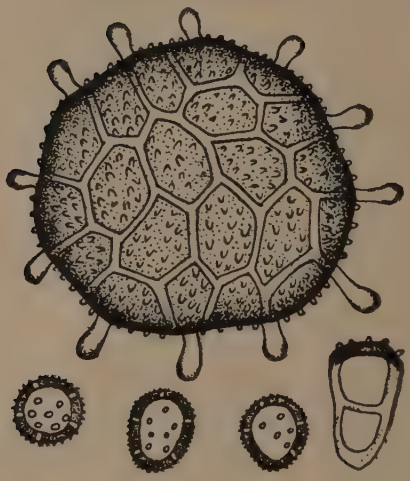


Fig. 89. Ravenelia.

Fig. 90 Scopella

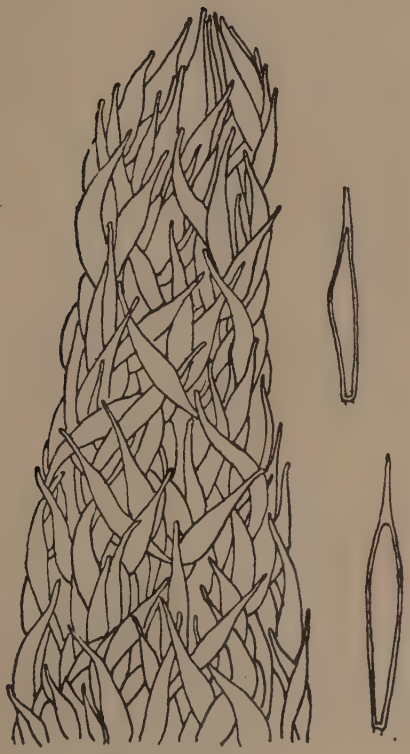


Fig. 91 Skierka

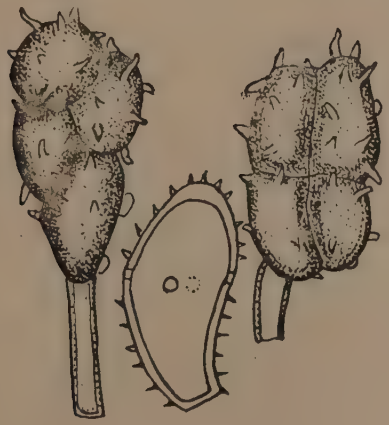


Fig. 92 Sphaerophragmium

Fig. 93 Sphenospora

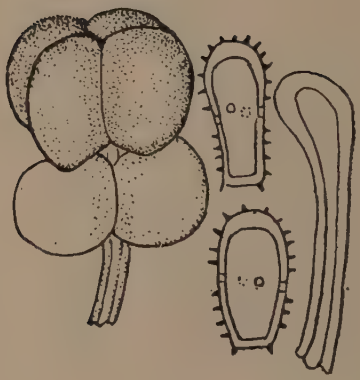


Fig. 94 Spumula

Fig. 95 Stereostratum

Fig. 96 Tegillum

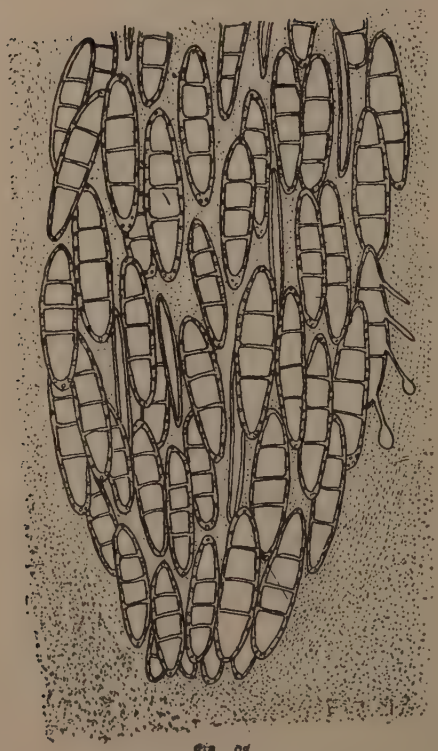


Fig. 98 Trichopsora

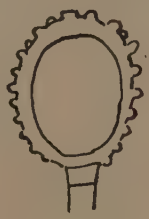


Fig. 97
Trachyspora

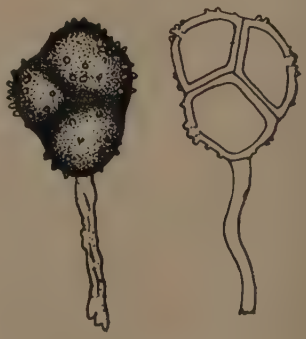


Fig. 99
Triphragmium

Fig 100 Trochodium

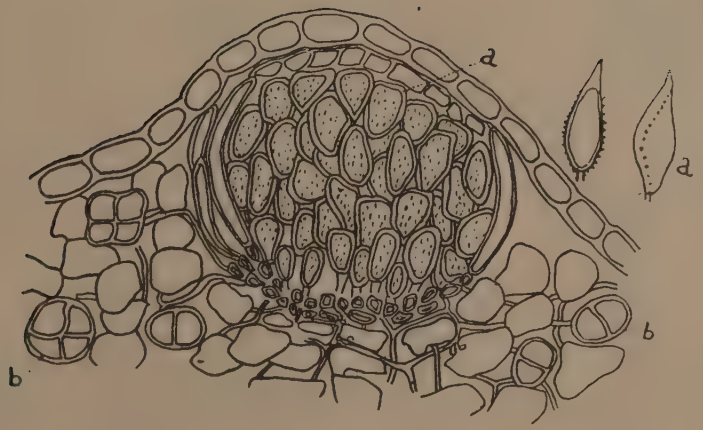


Fig 101 Uredinopsis.

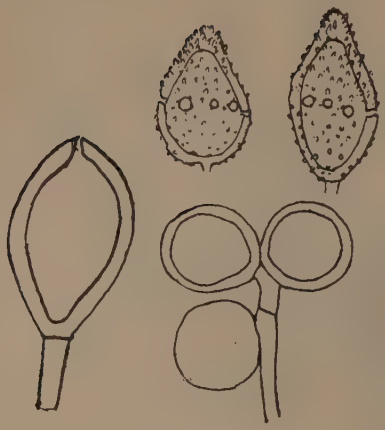


Fig. 102
Uromyces

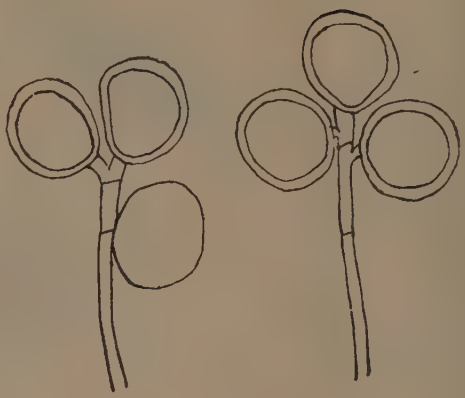


Fig. 103
Uromycladium.

Fig. 104
Uropyxis.

Fig. 105
Xenodochus

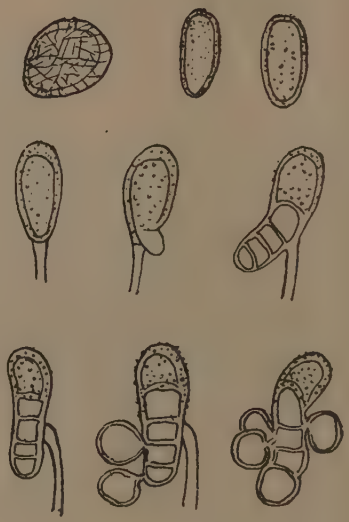


Fig. 106
Zaghohania.

SOME INTERESTING RUSTS OF SOUTH INDIA.

T. S. RAMAKRISHNAN.

(Accepted for publication June 7, 1950.)

Collections of fungal specimens were made recently from several places in South India among which a number of rusts were present. Some of these which are new or not previously recorded from India or found on new hosts are described in this paper.

ANGIOPSORA VERNONIAE sp. nov. (Fig 1&2)

Vernonia bourneana W. W. Sm. is common on Anamalais and Kodaikanal. In both the localities the plants were severely infected by a rust in November-December. Uredia were the predominant sori. These were scattered on the lower surface of the leaves imparting a yellow powdery appearance to the affected portions. Minute grey specks were present on the corresponding upper surface. Numerous peripheral incurved clavate paraphyses bordered the uredia. These were subhyaline, with irregularly thickened wall and often with a septum near the base. The urediospores were almost sessile being produced on short stalk cells. Germ pores were indistinct.

The telia were rare and observed only on some of the leaves collected at Kodaikanal as small black crusts mixed with the uredia. These were subepidermal and non-erumpent. The teliospores were catenulate, two to three layered and separated from each other when the sori were teased out. The epispore was smooth light brown and thickened upto 4μ at the apex. The morphological features of the rust indicated that it belonged to the genus *Angiopsora* (Mains 1934). This genus has not been recorded on *Vernonia* or the Compositae, and therefore the rust is described as *Angiopsora vernoniae*. The uredial stage bears resemblance to *Uredo perscita* Cummins recorded from Africa on *Vernonia amygdalina* (Cummins 1945).

ANGIOPSORA VERNONIAE sp. nov.

Pycnia and aecia not known; uredia hypophyllous, minute, numerous, 0.3-0.5 mm. in diameter, orange yellow, subepidermal, erumpent, pulverulent, paraphysate; urediospores globose, oval or elliptic, 26×21 μ (23—31×19—27), wall hyaline, orange yellow contents, echinulate.

Telia rare, hypophyllous, black, lenticular, subepidermal, upto 0.5 mm. in diameter; teliospores sessile, 2-3 layered, 1-celled, cantenulate, oblong or

angular, 30×13 μ (21—51×9—18), smooth, wall light brown, thickened at apex upto 4 μ.

Pycnia atque aecia ignota; uredia hypophylla, minuta, numerosa, 0.3 – 0.5 mm, in diam., lutea colore, subepidermalia, erumpentia, pulverulenta, paraphysata; urediosporae globosae ovatae vel ellipticae, 26×21 μ (23—31×19—27), membrana hyalina, contentis luteis colore, echinulata.

Telia rara, hypophylla, atra, lentiforme formantes, subepidermalia, usque 0.5 mm in diam., teliosporae sessiliae, unicellulares, 2 – 3 superpositae, 30×13 μ (21—51×9—18), leves, parietae diluto-brunneae, ad apice incrassata usque 4 μ.

On living leaves of *Vernonia bourneana* W. W. Sm., Kodaikanal, 26-xii-1949 (type): Anamalais 23-xi-1949 T. S. Ramakrishnan.

2. UREDO SCHUTERIAE sp. nov. (Fig 3)

Severe infection of the leaves of *Schuteria vestita* W & A. by this rust was prevalent at Kodaikanal in December. Uredia alone were present. These were amphigenous but more conspicuous on the lower surface and developed in groups of four or five or were sometimes formed singly on irregular dark olive spots. The sorus projected as a minute conical structure opening by a central pore. The opening was bordered by numerous hyaline club-shaped incurved paraphyses originating from a hyphal peridium. Through this opening the spores were liberated as white powdery masses. Telia were not seen in any of the specimens. The structure of the uredia suggests that the rust may belong to the genus *Phakopsora*. Several species of *Phakopsora* have been recorded on plants belonging to Papilionaceae. But in the absence of telia it is for the present placed in the form genus *Uredo*. No rust has been recorded on this host and it is named *Uredo schuteriae*.

Uredia amphigenous, mostly hypophyllous, isolated or in groups, subepidermal, erumpent, pulverulent, whitish, opening by a central pore bounded by numerous paraphyses; urediospores sessile, obovate, elliptic or subglobose, hyaline to subhyaline, finely echinulate, germ pores indistinct, 23—31×15—23 μ.

Uredia amphigena plerumque hypophylla, sparsa vel aggregata, subepidermalia, erumpentia, pulverulenta, albida, 0·1 - 0·2 mm. diam., dehiscentia perporum centralem paraphysibus pluribus circumdatum; urediosporae sessiles, obovatae, ellipsoideae vel subglobosae, hyalinae vel subhyalinae, minute-echinulatae, poris germinationis obscuris, 23—31 × 15—23μ.

On living leaves of *Schuteria vestita* W. A., Kodaikanal 26- xii -1949. T. S. Ramakrishnan.

3 UREDO NEILGHERRIENSIS sp. nov. (Fig 4)

The uredia of a rust were found infecting the lower surface of the leaves of *Parthenocissus neilgherriensis*. These were crowded minute and of a bright orange colour. The spores escaped through a central opening bordered by several rows of incurved subhyaline paraphyses Old sori had turned brown and exhibited a craterlike depression in the middle bounded by the ridge of the paraphyses after the escape of the spores. The urediospores were more or less sessile. Telia were not found. But the uredia suggest that the rust belongs to *Phakopsora*. *Phakopsora vitis* Syd. has been recorded on this host genus but it has been revised as *Angiopsora ampelopsidis* (Diet. & Syd.) Thirum. & Kern (1949). Since the uredia alone are present and the measurements differ to some extent from those of *Phakopsora vitis* it is advisable to place it in the form genus *Uredo* for the present. It is named *Uredo neilgherriensis*.

Uredia hypophyllous, circular minute, 0.1-0.2 mm. in diam., erumpent, pulverulent, bright orange, numerous peripheral paraphyses, incurved, subhyaline, urediospores obovate or elliptical 26 x 17μ (19 — 30 x 13 — 20), wall hyaline echinulate, contents orange coloured, germ pores indistinct.

Uredia hypophylla, rotundata, minuta, 0.1-0.2 mm. diam., erumpentia, pulverulenta, lutea colore, paraphysibus peripheralibus, peripheralibus plurimis, incurvata, subhyalina, urediosporae obovatae vel ellipticae, 26×17 μ (19—30× 13—20) membranis hyalinis, echinulatis, contentis luteis colore, poris germinationis obscuris.

On living leaves of *Parthenocissus neilgherriensis* Planchion., Kodaikanal, 26-xii-1949. T. S. Ramakrishnan.

4. ARTHURIA TYLOPHORAE sp. nov. (Figs. 5&6)

A rust was prevalent on *Tylophora mollissima* Wight. and *Tylophora tenuis* Bl, at Kodaikanal. Bright yellow sori were formed hypophyllously. Both aecia and uredia looked alike and could not be distinguished. Paraphyses were absent. The aecia were caeomoid without definite peridia. A layer of cells could be distinguished underlying the epidermal cells but this was unlike the usual peridium of aecia. The spores were catenulate. The telia were closely associated with the uredia, waxy and golden brown in colour but were very rare in the specimen. These characters lead one to the conclusion that

the rust may be included in the genus *Arthuria*. Only a few species of this genus are known. As these species are on hosts belonging to different families this rust is named *Arthuria tylophorae*.

Pycnia not observed, aecia caemoid, subepidermal, upto 0.5 mm., in diameter, hypophyllous, pulverulent, yellow; aeciospores catenulate, variously shaped, subglobose to angular, 29×18·5 μ (25—35×15—23), wall colourless, 1-2 μ thick, prominently echinulate. Uredia hypophyllous, scattered or gregarious, resembling the aecia; telia hypophyllous, few, minute, upto 0.3 mm., in diameter, golden brown, subepidermal; teliospore sessile, one-celled catenulate, 3—5 layered oblong to cubical, 19×13 μ (13—23×10—17), wall thin, smooth, subhyaline to light brown.

Pycnia ignota; aecidia caemoidea, subepidermalia, usque 0.5 mm. in diam,. hypophylla, pulverulenta, flavida; aecidiosporae catenulatae, variabilies, angulato-subglobosae, 29 × 18·5 μ (25 — 35 × 15 — 23), tunica hyalina, 1 — 2 μ cr., prominenter echinulatae. Urediosoris hypophyllis, sparsis vel gregaris, aecidiis similes. Telia hypophylla, rara, minuta, usque 0.3 mm. diam., aureo-brunnea, subepidermalia; teloosporae sessiles oblongae vel cubicae, 19×13μ (13—23× 10 — 17) unicellatae, catenulatae 3—6 superpositae, membranis tenuis, levibus, subhyalinis vel dilute brunneis.

On living leaves of *Tylophora mollissima* Wight., Kodiakanal, 26-xii-1949 (type) ; *T. tenuis* Bl., Kodaikanal, 26-xii-1949, T. S. Ramakrishnan.

5. PUCCINIA PICRIDIS. Haszl. Brand & Rostp. Saccardo, P. *Syll. Fung.* **7**; 652, 1888.

Widespread on the leaves of *Pricris heiracioides* L. at Kodaikanal in December. Both the uredia and telia were present. This rust has not been recorded in India.

6. PUCCINIA MELOTHRICOLA. Syd. *Ann. Myc. 15;* 172, 1917.

On the leaves of *Melothria mucronata* Cogn , at Ootacamund in October. The telia alone were present This has not been reported from India.

7. AECIDIUM PULNEYENSIS. Ramakrishnan and Srinivasan sp. nov. (Fig. 7)

This rust is common on *Canarium commune* L., in the neighbourhood of Kodaikanal. The infection is apparently perennial causing the formation of witches brooms on different branches. Clusters of thickened short curved

twigs are formed. Hypertrophied spots develop on the leaflets also. The witches brooms are yellowish brown when young. The swollen portions are studded with minute black subcuticular pycnia. These are hemispherical and a few are open with hyphae in the ostiolar openings. Innumerable cupulate aecia are imbedded in the hypertophied portions of leaves and stem. These project above the surface with white lacerated peridia and red brown contents. Uredia are sparsely formed on the lower surface of the leaflets. These are bright reddish orange with several rows of incurved paraphyses. Telia are not observed.

Two rusts *Skierka canarii* Racib. and *Skierka philippinensis* Cummins. have been recorded on this genus. The rust under study does not possess telia but is obviously not *Skierka*. It is for the present placed in the form genus *Aecidium*, and named *Aecidium palneyensis*.

Pycnia foliicolous and caulicolous amphigenous , subcuticular, black, minute upto 100 x 60μ. Aecia foliicolous and caulicolous, cupulate, deeply immersed, 0.5 to 0.8 mm., broad and upto 2mm. long; peridium white, peridial cells polygonal, prominently verrucose, or reticulate, 41 – 50 x 17 – 27 μ; aeciospores of various shapes, reddish brown, wall irregularly thickened, prominently verrucose or reticulate, upto 5μ thick, 33 x 20 μ (23 – 46 x 17 – 23); uredia hypophyllous, subepidermal orange red, erumpent, pulverulent, with peripheral incurved paraphyses ; urediospores pedicellate, obovate or elliptical. 29 x 21 μ (23 – 25 x 15 – 23), wall hyaline, strongly verrucose contents orange coloured,; telia not seen.

Pycnia foliicola, et caulicola, amphigena, subcuticularia minuta, usque 100 x 60 μ; aecdia in foliis et caulibus, disposita, cupulata, profunde immersa, 0.5 to 0.8 mm. 1st.. useque 2mm. alt; predium albidum, cellulis angulatis, prominenter verrucosis vel reticulatis, urediosorae hypophyllae, subepidermales, erumpentes, pulverulentae, paraphysibus peripheralibus, incurvatis ornatae: urediosporae stipitate obovatae, vel ellipticae, 29x21 μ (23 – 35 x 15 – 23), membranis hyalinis, prominenter verrucosis contentis luteis colore; telia non visa.

On living stem and leaves of *Canarium commune* L. Kodaikanal, 23 - xii - 49. K. V. Srinivasan.

8. CHACONIA BUTLERI (Syd) Mains. *Bull. Torr. Bot. Club.* 65, 628, 1938

On living leaves of *Jasminum brevilobum* Kodaikanal, 23 - xii - 1949, K. V. Srinivasan. Ootacamund, 3 - xii - 1949, K. Ramakrishnan.

This rust was observed on the leaves of *Jasminum brevilobum* at Kodaikanal and Ootacamund in December. The uredia were alone present but the characteristic arrangement of the echinulations on the urediospores and the spore measurments leave no doubt that the rust is *Chaconia butleri*.

9. PUCCINIA LEUCADIS Syd. *Mon. Ured.*1 : 281, 1904

On leaves of *Leucas linifolia* Spr. all over Kodaikanal in December. Uredia were more common.

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Coimbatore.

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Fig. 1. *Angiopsora vernoniae.* Section of uredium (Centre); Urediospores (left) and paraphyses (right) (x 200)

Fig. 2. *Angiopsora vernoniae* Section of telium; 4 telios and pores (right) (x 200)

Fig. 3. *Uredo schuteriae* Section through uredium (x 200)

Fig. 4. *Uredo neilgherriensis* Section of uredium (x 200)

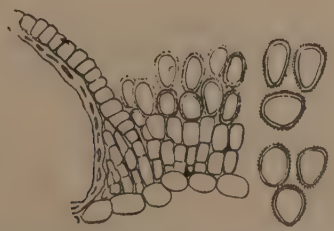

Fig .5. *Arthuria tylophorae*, portion of aecium with mature spores (right) (x 200)

Fig. 6. *Arthuria tylophorea* Section of young telium (x 200)

Fig. 7. *Aecidium pulneyensis*

(a) Pycnium (b) Peridial cells. (c) Aeciospores (d) Section of uredium (all x200)

BACTERIAL LEAF-SPOT OF COTTON

M. K. Patel and Y. S. Kulkarni

(Accepted for publication August 21, 1950.)

Introduction

The pre-war area under cotton cultivation in India was about 20 mllion acres. Besides the two main indigenous species viz. *Gossypium arboreum* and *G. herbaceum* growing in different tracts, attempts to introduce exotic types mainly belonging to *G. hirsutum* have been sucessful in the Punjab, Sind, C. P. and Berar, the Karnatak and the Madras State. Uppal (1948) in his exhaustive monograph on diseases of cotton in India has mentioned the occurrence of angular leaf-spot of cotton as of minor importance, probably because the indigenous cottons are somewhat resistant to this disease. The disease caused by *Xanthomonas malvacearum* (Sm.) Dowson is common mainly on *G. hirsutum* types at Viramgam, Broach, Surat, Jalgaon, Dharwar and Gadag in the Bombay State. It is also reported from C. P. and Berar, Parbhani in the Hyderabad State, besides Madras where according to Balasubrahmanyan (1949) it is confined to parts with eco-climatic condition normally congenial for its incidence. This paper forms a detailed account of a short note by the authors (1948).

Distribution and Economic Importance

Smith was the first to prove the parasitism of the bacterium in 1901 and named it *Bacterium malvacearum* in 1905. The disease occurs in all cotton growing countries of the world and according to Smith (1920), the disease in Asia and Africa is identical with that in the U. S. A. In Sudan, the cultural and climatic conditions under which 'Sakel' cotton *(G. barbadense)* is grown, are so favourable for the development and spread of the disease that even a mild attack can reduce the yield by about 25 per cent. In India, in the Madras State, the disease becomes very serious on exotic types (*G. hirsutum*) if it rains during December-January. Although no systematic survey regarding suceptibility or resistance of the two species to this disease has been made, some Persian and Russian types (*G. herbaceum*) and Jarila (*G. arboreum*) have been found to be highly susceptible at Viramgam and Jalgaon farms respectively. Since the pathogen was not cultured in a pure state anywhere in India, investigations were undertaken to isolate it from diseased leaves and study its morphology, physiology, its carry-over from season to season and test the reactions of indigenous as well as exotic types of cotton to the disease.

SYMPTOMS OF THE DISEASE

The disease closely resembles the one described by E. F. Smith which is characterised by minute, water-soaked spots measuring initially 1 to 2 mm. on the lower side of young leaves. These spots look translucent when held against light. With the progress of the disease, the spots increase in diameter upto 5 mm. and become angular because the bacteria develop in the parenchyma and are checked by the larger veins. After a few days, such spots turn brown with purplish margins, turn black and are visible on the upper surface. (Pl. I. figs. 1-8). Gummy bacterial exudations in the form of a crust or scales are often found on the under surface of leaves. When the disease extends along the edges of the mid and lateral veins (Pl. I, figs. 7-8), it is known as 'black vein'. When several lesions coalesce and veins are attacked, the leaf looks typically wrinkled (Pl. I, fig. 10). Such leaves turn yellow and fall to the ground.

If the stems of seedlings are attacked as is the case with American cottons in Gadag tract, the plants may be killed. In advanced stages of the plant, the disease produces elongated, grayish to sooty black lesions on stems, branches and petioles. Heavily attacked stems show deep cracking and gummosis and can be easily broken by wind while the infected petioles continue to hang down. This stage of the disease is known as 'black-arm'.

Intection of bracts is more visible in the case of very susceptible cottons like 'Sakel' (*G. barbadense*) (Pl. I. fig. 9). Very young bolls when infected are often shed. Advanced bolls in the succulent stage show round, raised, water-soaked spots, which later become irregular in shape, brown to deep black in colour and depressed in the centre. (Pl. I. fig. 11). Bacterial ooze in the form of small shining beads is found in the centre of such spots. Badly affected bolls remain small, shrunken and drop down. Mature bolls when attacked open prematurely; the lint from such bolls being stained yellow, is valueless (Pl. 1 fig. 12).

ISOLATION AND INOCULATION EXPERIMENTS

The pathogen was easily isolated from the diseased leaves and bolls by usual poured plate method. Pale yellow, glistening colonies began to appear after 2-3 days at room temperature.

Inoculation of leaves and stems :— One month old Co2 (*G. hirsutum*) plants with 2 or 3 leaves growing in sterilised soil in 6" earthen pots were selected. The plants were kept under a bell-jar for 24 hours to create high humidity so necessary for successful infection. Multiple punctures and vertical

scratches were made on leaves and stems respectively. Suspension of a well-developed culture was sprayed on all parts of the plants specially the undersurface of the leaves. Control plants were sprayed with sterile water only. The plants were again placed under the bell-jar for 24 hours before removal to the glass-houses for further observations. Small water-soaked spots on tender leaves and elongated grayish-black areas on punctured stems appeared after 4 and 7 days respectively. The organism reisolated from the necrotic tissues resembled the original culture in all respects. Control plants remained healthy throughout the period of observation.

Inoculation of bolls :— Succulent bolls of Co2 plants (*G. hirsutum*) were punctured and sprayed with bacterial suspension on a cloudy day after profusely watering them. Immediately after spraying, such bolls were covered by means of tissue paper bags with little moist cotton wool inside, which helped to create a film of moisture round the boll. After an incubation period which ranged according to the season from 5 to 13 days, there appeared on bolls round, raised, water-soaked spots.

MORPHOLOGY OF THE ORGANISM

The organism is a short rod with rounded ends, either single or in pairs, never in chains and has no involution form. In cultures on potato dextrose agar varying in age from 1 to 3 weeks, the average dimensions are 1. 2μ x 0.9 μ; motile by a polar flagellum; gram-negative; not acid fast; capsulated; non-spore former; and stains readily with common dyes.

CULTURAL CHARACTERS

On potato dextrose agar slants, the growth is copious, raised, smooth, glistening, filiform, consistency butyrous, flowing to the bottom of the tube, with no distinctive odour. On potato dextrose agar plates, the colonies are round, glistening, convex, butyrous, colour baryta yellow (R), with no distinctive odour and medium being unchanged in colour with internal markings (striations) starting from the centre and coming up to the periphery and measure 2 cm. in diameter in 7 days. In nutrient agar plates the growth is poor, thin, flat, glistening, pale yellow with no distinctive odour, the medium being unchanged in colour. In nutrient broth, the growth is slow in the first 24 hours, becoming moderately cloudy with no pellicle and floccules in the next four days, the medium being unchanged in colour. On potato cylinders, the growth is copious, raised, shining, deep yellow flowing and covering the entire surface in 4 days with no darkening of the cylinders. In plain milk, the growth is fair, the medium clearing after 4 days. Litmus is completely reduced in 8 days, casein

partly digested without coagulation. The pathogen is a facultative aerobe. In Starr's tyrosine media, the organism makes some growth as judged by the colour reaction. The optimum temperature for growth lies between 31°-32°C., while the growth ceases at 6° and 42°C. The thermal death point is 50°C.

BIOCHEMICAL REACTIONS

The organism liquefies gelatin and is able to digest starch and casein. The colour of the lipolytic medium is not changed showing its inabilility of digesting fats. Hydrogen sulphide is produced; nitrites are not produced; indol not produced, M. R. and V. P. tests negative; no growth in Cohn's and very little or no growth in Uschinsky's solutions: tolerant to 3 per cent sodium chloride; Loeffler's solidified blood serum not liquefied in 10 days. The organism grows well on several synthetic carbohydrate media containing separately 1 per cent dextrose, galactose and lactose with production of acid but no gas. It does not utilise xylose, arabinose, raffinose, mannitol and salicin. Asparagine is not utilised.

LONGEVITY

Uppal, Patel and Nikam (1946), Patel and Moniz (1948) and Patel and Diwan (1949) have reported that *Xanthomonas phaseoli* (Erw. Smith) Dowson var. *indicus* causing blight of French beans (*Phaseolus vulgaris* L.), *X desmodii-gangeticii* Uppal, Patel and Moniz, causing leaf-spot of *Desmodium gangeticum* and X. *vignicola* Burkholder causing blight of cowpea respectively remained viable for about 5½ months at 13°C. In order to find out the longevity of *X malvacearum* at 13°C., loopfuls of a well grown culture on potato dextrose agar were transferred to sterile cover slips in a sterile petri dish kept in an ice box. At regular intervals a cover slip was dropped aseptically in a tube of nutrient broth and incubated at 31°C. Control cover slips were also provided. Inoculated cover slips continued to give good growth in nutrient broth which when sprayed on young Co2 (*G. hirsutum*) plants gave positive infection upto three months.

Uppal, Patel and Nikam (1946) and Patel and Diwan (1949) found that cultures of *X. phaseoli* var. *indicus* and *X. vignicola* growing in peptone dextrose broth, when transferred by means of a loop on sterile cover slips and incubated at 31°C., remained alive for 17 and 7 days respectively. Similarly the culture of *X. malvacearum* growing in peptone dextrose broth when transferred to sterile cover slips was found to resist desiccation for 16 days at 31°C. but the same culture growing on potato dextrose agar when transferred to sterile cover

slips remained virulent for a period of 60 days probably because the number of organisms from potato dextrose agar medium is greater, affording protection to some organisms next to the cover slips.

TRANSMISSION OF THE DISEASE

It has been proved experimentally by Faulwetter (1917) that the disease is transmitted through seed although the percentage of such primary infection is very little and also that, wind-blown rain is an important factor in further spread of the disease. In order to obtain reliable evidence on the transmission of the disease from season to season, the following experiments were made :-

Experiment I :— Seeds from badly affected bolls of 'Sakel' (*G. barbadense*) just after picking in April, were delinted by means of a sterile forceps and were dropped one each in a tube containing peptone dextrose broth. After incubation at 31°C for 3 days, good cloudy growth was observed in 7 out of 10 tubes, which when sprayed on susceptible plants gave positive infection on leaves showing that seeds can become a source of infection. To further prove whether the same seeds from infected bolls can carry over the organism from the date of picking (first week of April) to the date of sowing (first week of June), sowings were made in pots filled with sterilised soil with such infected seeds delinted with commercial sulphuric acid. One out of 10 seedlings showed a necrotic spot with a clear halo on the cotyledons indicating that the infected seeds are a potent source of primary infection although the percentage of such infection is small.

Experiment II :— In this experiment, infected leaves of cotton were collected and stored in a paper bag at room temperature. At regular intervals of 10 days from the date of collection, the infected leaves were crushed and soaked in water for about an hour. The decanted liquid was then sprayed on susceptible plants. Infection could thus be obtained 290 days after the date of collection showing that plant debris, mostly dry infected leaves lying in the crevices of the soil, is another very important source of carry-over of the disease from one season to another even though the seed may come from a healthy locality. These results are in conformity with those of Massey (1930) and Weindling (1948).

Experiment III :— To the sterilised soil in tubes was added nutrient broth previously inoculated with the culture of *X. malvacearum* and kept at room temperature (30°C). At regular intervals, a bit of this inoculated soil was dropped by means of a sterile scalpel in a tube containing nutrient dextrose broth, which after a short incubation of 3-4 days was sprayed on young cotton leaves

of a susceptible variety. Positive infections on leaves were obtained 120 days after inoculation of the sterilised soil. In this connection, it is of interest to note Patel's findings (1929) that the organisms such as *Bact. tumefaciens*, *Bact. marginatum*, *X. phaseoli*, *Bact. carotovora*, and *Bact. atroseptica* live for more than 500 days in sterilised soil.

Experiment IV. :— This experiment was designed to find out whether volunteer cotton plants can carry over the disease from season to season. For this purpose, susceptible cotton plants in the field were inoculated with *X. malvacearum* in the first week of March 1948. After a period of 12 days, both leaves and bolls showed good symptoms of disease. During the months of April and May which are very hot, further increase in the disease was not observed but in the first week of June 1948, when pre-monsoon conditions generally prevail, fresh infection of young leaves and young bolls could be observed. This clearly shows that some infected volunteer plants in a field can carry over the pathogen during adverse climatic conditions and serve as a source of primary infection when favourable environmental conditions for the disease appear.

HOST RANGE

As suggested by Smith (1920), several Malvaceous hosts which in nature grow wild as hedge plants or are cultivated were grown in sterilised soil in pots and inoculated as described earlier. The organism failed to infect *Abutilon indicum*, *Althea rosea*, *Hibiscus abelmoschus*, *H. cannabinus*, *H. esculentus*, *H. tetraphyllus* and *Sida rhombifolia*.

Reaction of exotic and indigenous cotton types to the angular leaf-spot disease :— Although Knight (1948) tested the reaction of a number of varieties of both the new and old World cottons to blackarm disease, there are no authentic data regarding the behaviour of these types to the disease under Indian conditions. Seeds of exotic cottons and popular Indian cotton varieties received from the regional Cotton Breeders were grown in pot-culture and also under field conditions. Plants in pot-culture were kept below bell-jars for 24 hours before and after spraying with bacterial suspension while plants growing in the field were sprayed with the pathogen by bucket sprayer late in the evening. Their reactions are given in Table I.

TABLE I. : *Reactions of foreign and Indian cottons to blackarm*

Variety	Species	* Reaction	Remarks
New World (cultivated)			
Sakel	*G. barbadence*	+ +	
Sea-Island	,, ,,	,, ,,	
Boss	,, ,,	,, ,,	
Kidney cotton	,, ,,	,, ,,	
Moco	*G. purpurascens*	,,	
Co2	*G. hirsutum*	,,	(Pl. I, fig. 7-8)
L. S. S.	,, ,,	,,	
M4	,, ,,	,,	
Sind-Sudhar	,, ,,	,,	
Perso-American	,, ,,	,,	
Jinjiya	,, ,,	,,	
Kampala	,, ,,	,,	
4F-98	,, ,,	,,	
4411-3	,, ,,	,,	
BAR7/1 (B_2B_2)	,, ,,	,,	
BAR7/6 (B_3B_3)	,, ,,	,,	
BAR7/8 ($B_2B_2B_3B_3$	,, ,,	Small rouud spots.	
New World (Wild)			
(N=26 chromosomes)	*G darwinii*	+	
,,	*G. tailense*	Slight infection	
(N=13 chromosomes)	*G. harkensii*	,, ,,	
,,	*G. thurberi*	+	
,,	*G. davidsonii*	Slight infection	
,,	*G. raimondii*	,, ,,	
,,	*G. trilobum*	,, ,,	
Hybrids between new and old world cottons			
(125 x Co2)3–5–5–4 –Bulk–10–F8	*G. arboreum* x *G. hirsutum*	+	
(134 x Co2)F1 x C, W.1–3–Bulk–1–F6	*G. herbaceum* x *G. hirsutum*	,,	
(134 x C. W.)– 7–1–1–1–1–6–F6	,, ,,	,,	
(125 x Co2)–3–3–1 –3–Bulk–16–F8	,, ,,	,,	
(134 x C. W.)–3–2 –1–1–1–F7	,, ,,	,,	
(68F3 x 22)–F4–6– 2–1–1–2–F7	*G. hirsutum* x *G. arboreum*	,,	

TABLE I (contd.)

Variety		Species	* Reaction	Remarks
Old World (wild)				
(N=13 chromosomes)		*G. anomalum*	Slight infection	
Old World (cultivated)				
Baluchistan	2	*G. herbaceum*	+	
,,	3	var. *typicum*	,,	
,,	6	,, ,,	,,	
,,	7	,, ,,	,,	
Persian	34	,, ,,	,,	
,,	72	,, ,,	+ +	
,,	74	,, ,,	,, ,,	
,,	106	,, ,,	,, ,,	
,,	205	,, ,,	,, ,,	
,,	210	,, ,,	,, ,,	
,,	211	,, ,,	,, ,,	
Per. Loc. iii	–1	,, ,,	,, ,,	
,,	–2	,, ,,	,, ,,	
Per. Loc. vi	–1	,, ,,	,, ,,	
Russian	4	,, ,,	,, ,,	
,,	5	,, ,,	,, ,,	
,,	7	,, ,,	,, ,,	
,,	19	,, ,,	,, ,,	
,,	20	,, ,,	,, ,,	
,,	22	,, ,,	,, ,,	
,,	25	,, ,,	,, ,,	
,,	42	,, ,,	,,	
,,	46	,, ,,	Slight infection	
Cutch wagad	–3	*G. herbaceum*		
C. W.	42	var. *frutescens*	+	
,, ,,	1509	,, ,,	,,	
,, ,,	1579	,, ,,	,,	
H.	8–1	,, ,,	,,	
K.	72–2	,, ,,	,,	
Wagad	4	,, ,,	Slight infection	
,,	8	,, ,,	,,	)Very clear
,,	12	,, ,,	,,	)infection on
,,	14	,, ,,	,,	)Viramgam
,,	26	,, ,,	,,	)Farm
,,	87	,, ,,	,,	
,,	96	,, ,,	,,	
,,	99	,, ,,	,,	
,,	126	,, ,,	,,	
,,	163	,, ,,	,,	
,,	293	,, ,,	,,	
,,	305	,, ,,	,,	
W. J.	179	,, ,,	,,	

TABLE I (contd.)

Variety	Species	* Reaction	Remarks
Seg. 8–1	*G. herbaceum* var. *frutescens*	Slight infection	Around punctures
B. D. 4	,, ,,	,,	Around punctures
B. D. 6	,, ,,	,,	,,
B. D. 8	,, ,,	,,	,,
G. E. 5	,, ,,	,,	,,
G. A. 26	,, ,,	,,	,,
Seg. 1–2	,, ,,	,,	,,
Seg. 1–6	,, ,,	,,	,,
1027 A. L. F.	,, ,,	,,	,,
W. J. 197	,, ,,	,,	
1. A. L. B.	,, ,,	,,	,,
N. S. 12	,, ,,	,,	,,
R. K. 19	,, ,,	,,	,,
Hagari	,, ,,	,,	,,
K. F.	,, ,,	,,	,,
Karkhadi	*G. arboreum* x *G. herbaceum* hybrid	,,	)Good lesions)around)punctures in
Rozi	*G. arboreum* var *typicum*	,,	)the field)
Red Arboreum	*G. arboreum* race *bengalense*	,,	))
New Million Dollar	*G. arboreum* var. *neglectum*	,,	Around punctures
Chinese R1	,, ,,	,,	,,
Dhulia 2	,, ,,	,,	,,
N. R. 5	,, ,,	,,	)Good spots
Seg. 197–3	,, ,,	,,	)in the field)at Jalgaon
N. R. 6	,, ,,	,,	
Jarila	,, ,,	,,	Heavy infection
Dokras	,, ,,	,,	on Jalgaon
Gaorani 6	,, ,,	,,	Farm (Pl. I. figs. 1-6)

* , + + , and , + , mean high and mild susceptibility similar to grades 9-12 and grades 3-8 respectively of Knight and Clouston (1939) while slight infection means water-soaked areas around punctures and a few angular spots due to stomatal infection resembling grades 0-2.

DISCUSSION

The organism causing angular leaf-spot of cotton in India closely resembles the one described by Smith (1920) in morphological, cultural and physiological characters. The disease must have been introduced in India through foreign cotton seed as attempts to introduce and acclamatise foreign types in India were made as early as middle of the nineteenth century by the East India Company. It has been however, lately argued by Knight (1948) that the disease originated in the Old World, probably India, as Indian cottons have been subjected to a selection pressure by blackarm for a longer period than the New World cottons. Trials of various foreign types are still being made at various research stations in this country. From table I, it is clear that the cultivated foreign types are either highly or mildly susceptible, while most of the Indian types belonging to *G. herbaceum* and *G. arboreum* are highly resistant and show some water-soaked areas when punctured. It is surprising, however, to find that Russian, Persian and Baluchistan *herbaceums* (*G. herbaceum* var. *typicum*) are very highly susceptible. Smith (1920) isolated the bacterial leaf-spot organism from cotton samples received from Russian Turkestan and the cotton referred to by him must be one of the Russian *herbaceums*. Before using one of these Persian or Russian *herbaceum* types for hybridisation with Indian types with a view to combine silky fibre and early maturity of the former, it would be interesting to study the mode of inheritance of blackarm resistance under optimum conditions of infection.

Although primary infection can be avoided by seed treatment, the more potent source of initial infection through infected plant debris and volunteer plants still remains. The only solution of the problem lies in the breeding of resistant types under ideal conditions of infection. Recently Jarila and N. R. 5 thought to be highly resistant to this disease were found to be severely affected at Jalgaon. This observation is quite striking and it is, therefore, safer to test the improved types for their resistance to this disease before distributing them to the growers, as this disease combined withoher leaf-spot diseases is likely to affect the yield ultimately.

SUMMARY

Angular leaf-spot of cotton is a disease of common occurrence on exotic types in the Gadag tract and the Madras Province.

The organism is identical with the one described by E. F. Smith in almost all morphological, cultural and physiological characters.

The disease is transmitted by infected seed, infected plant debris and volunteer plants.

It is inferred that the disease was introduced in India on seeds although Knight (1948) thinks otherwise.

The organism fails to infect other Malvaceous plants.

All foreign cultivated cotton types are susceptible but types belonging to *G. barbadense* show a higher degree of susceptibility.

Of the old world cottons, Russian, Persian and Baluchistan *herbaceum* cottons (*G. herbaceum* var *typicum*) are susceptible. Indian cottons with the exception of a very few show high degree of resistance.

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EXPLANATION OF PLATES

PLATE I

Figs. 1-2. Leaves from N. R. 5 and 197-3 with few spots, showing resistance of grades 3-8 of Knight and Clouston.

3-6. Leaves of N. R. 6, Jarila, Dokras and Gaorani with greater infection resembling grades 9-12 of Knight and Clouston.

7-8. Leaves of Co2 cotton showing typical angular leaf spots and vein attack.

9. Infection on the bract of 'Sakel' cotton.

10. Typically wrinkled leaf of 'Sakel' cotton due to infection of veins.

11. Green cotton boll showing round, water-soaked, irregular, centrally depressed, brown to black spots.

12. Boll opening prematurely resulting in yellow stained lint.


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OBSERVATIONS ON THE BLACK ARM OF COTTON IN MADRAS STATE.

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Black arm, angular leaf spot or bacterial disease of cotton caused by *Xanthomonas malvacearum* (Smith) Dowson has been prevalent in the Madras Province for over 30 years. The first record of the disease was in the year 1918 from Rajapalayam, Ramnad district on *Gossypium hirsutum* L. Since then it has been observed in several other districts viz., Coimbatore, Salem, Ramnad and Bellary almost every year, being very severe in some years and less conspicuous in others. Patel and Kulkarni (1948) mention that they have isolated *X. malvacearum* for the first time in India from exotic cottons. Ballard and Norris (1923) have stated that angular leaf spot disease due to *B. malvacearum* has "been shown to occur in other parts of the presidency" (Madras). Investigations on the seed treatment for the control of the black arm of cotton common on exotic cottons in the province have been carried out by this section for several years and mention has been made about this in the administration reports of this section (Thomas 1941). These indicate that black arm of cotton caused by *X. malvacearum* has been engaging the attention of several workers in South India for a long time.

The disease has been found to be more destructive on exotic cottons e. g, *Gossypium hirsutum* and *G. barbadense* L. The types of Egyptian cotton grown at the Agricultural Research Station, Siruguppa, Bellary district, were almost destroyed by the disease in 1940. At Srivilliputhur the crops of Cambodia cotton (*G. hirsutum*) are invariably subject to black arm infection year after year. Its incidence in Coimbatore has been noticed repeatedly. The disease is initially manifested in the form of small dark brown angular spots on the leaves, visible on both sides. In the beginning these have a watersoaked dark green colour on the lower surface but soon turn dark brown. Numerous spots develop on a leaf. In some instances the infection proceeds along the veins which are blackened. When the basal veins are affected to a large extent the leaf blade shrivels up. Petioles also exhibit darkening along restricted or extensive areas. Shedding of affected leaves may occur in extreme cases. The greatest damage is however caused by the infection occurring on the flowering branches which shrivel and dry up resulting in the loss of flowers and bolls. The diseased shoots become blackened.

MATERIALS AND METHODS.

The varieties and cultures of cotton referred to in this paper were grown at the cotton breeding station, Coimbatore, where a large collection is being maintained. Seed disinfection experiments were carried out at Coimbatore for the control of the disease for two seasons. Naturally infected seed of a susceptible culture viz., Co.2, kindly supplied by the Cotton Specialist, were used in the experiments. Seed treatment was carried out after delinting the seed with concentrated sulphuric acid (followed by washing and drying) or without removing the fuzz. Formalin was applied in two ways. In one series the seeds were steeped in one percent solution of formalin (40 percent formaldehyde) for either 10 minutes or 20 minutes, taken out and dried. In the other series formalin charcoal dust was prepared by thoroughly mixing fine charcoal powder passing through 300 mesh sieve with ten percent by weight of pure formalin (40 percent formaldehyde). This dust was used at the rate of one gram per pound of seed. The seeds were shaken with the powder for 15 minutes and stored in drill bags or sown immediately. Ceresan and Agrosan G. were used at the rate of one gram per pound of seed and shaken well for 15 minutes. The effect of the treatment was first tested in pot experiments and was later followed by field trials. Periodical counts of the plants were taken and the intensity of infection recorded. The field trials for the evaluation of resistance to black arm were conducted on the lines followed by Knight and Clouston (1939) and Knight (1946). The bacterial suspensions were made from naturally infected leaves or from agar cultures. The intensity of leafspot infection was graded into 8 classes ranging form 0 exhibiting absolute freedom to 7 showing the maximum infection. The first four leaves in a plant were graded and the average calculated. Branch infection was classified into four groups viz., free, light, medium and heavy infection, depending on the number of branches infected. Category values were allotted to each of the groups and the mean degree of infection for the selection arrived at for purposes of analysis.

RAINFALL AND INCIDENCE OF DISEASE

The incidence of the disease has been observed all through the year when the crop is retained on the field. But it becomes severe only in particular seasons. In Coimbatore it is common from October to March. The crop is sown in September and remains in the field till April to May. The angular lesions are evident even on the cotyledons and veinal lesions may develop on the first leaf. The intensity of infection is found to be closely related to the rainfall during the months of October to January. In the year 1947 the North-east monsoon was a failure and the disease was absent. Even artificial infection by spraying a suspension of the bacteria in the field had no effect in inducing infection in the experimental plots. But in 1946 when the rainfall was heavier severe infection was observed. The quantity of rainfall during October to March, the number of rainy days and the relative incidence of the disease at the cotton breeding station, Coimbatore, are given in Table 1.

TABLE I. : *The rainfall, number of rainy days and the incidence of black arm at the cotton breeding station, Coimbatore*

	1945-46			1946-47			1947-48			1948-49		
Months.	rain fall inches	No. of Rainy days	Infection	rain fall inches	No. of Rainy days	Infection	Rain fall inches	No. of rainy days	Infection	Rain fall inches	No. of rainy days	Infection
October	11.16	13	Heavy infection - angular leaf spot and shoot infection heavy.	8.06	11	Heavy infection - angular leaf spot and shoot infection heavy.	3.19	7	Nil to very light infection-angular leaf spot alone prevalent in October.	4.29	9	Medium infection angular leaf spot and shoot infection.
November	5.69	9		7.72	11		1.45	2		4.46	9	
December	0.30	1		4.14	8		0.12	1		0.63	2	
January	0.59	1		0.31	2		0.91	2		-	-	
February	-	-		0.01	-		-	-		0.13	1	
March	0.64	2		0.71	2		0.22	1				
Total	18.38	26		20.95	34		5.89	13		9.51	21	

The field observations and records of the experimental plots show a correlation between rainfall (including the number of rainy days) during October to January and the intensity of infection. During 1946-47 the rainfall was the highest; the intensity of infection was also the heaviest.

VARIETIES OF COTTON AND THEIR REACTION.

The intensity of infection varies according to the variety of cotton under cultivation. All the varieties are not equally affected. Several species, varieties and cultures are grown on the cotton breeding station at Coimbatore. These were individually examined in November in the field and the incidence of infection on each one of them was recorded for two seasons. The incidence has been computed as crop infection taking into account the number of plants of the population of a particular culture exhibiting the disease and expressing it as percentage of population of the culture. A plant was classified as infected when at least four leaves had several lesions on them. The results are given in Table II.—

TABLE II.

Crop infection in different cultures during 1940-41 and 1941-42.

Species and cultures	Crop infection per cent.	
Gossypium hirsutum	in 1940-41	in 1941-42
Acala Texas	85	54
Buri white	71	86
Buri khaki	91	98
Buganda	50	60
Cleveland big boll	100	48
Codda	41	72
Co. 1	100	85
Co. 2	97	100
Co. 3	98	100
Dixie Triumph	18	45
Durango 5	42	72
Express bulk	X	53
Ferguson 006	20	54
Gadag	91	82
Jinja	30	65
Harper Martindale	43	70
Hyderabad American	51	81
Herbacao	72	85
Indore I	35	76
Iraq hirsutum	100	100
Kampala	32	57
Lankort	20	90
Lone Star	78	61
„ U. S. A.	48	79
Mebane 804	40	84
„ 141	32	56
Mexican big boll	34	53

Table II. (cont.)

Speciel and cultures	Corp infection per cent. in 1940-41	in 1941-42
Mysore American	85	76
Nye's B 31	X	15
Pay master	58	42
Persian hirsutum	40	74
Qualla	27	100
Russian hirsutum 2284	92	93
Sind Mysore American	X	100
Sinkiang hirsutum	76	80
Sudan	78	100
Texas Mammoth	15	44
U 4/2	38	100
Zululand hybrid	98	100
G. hirsutum mariegalantie (Watt) Hutch. et. al.		
Moco	50	X
G. hirsutum var. *punctatum* (Schu.) Hutch et. al.	87	90
Bourbon Gossypium barbadense.		
Ashmouni bulk	65	100
Foudi bulk	75	100
Giza	70	100
Ishan	35	77
Maraod	75	100
Red Sea Island	45	89
Sakel bulk	65	88
Sakha	58	100
Sea Island	72	100
Sind boss	70	100
Sind Egyptian	63	100
Verdao bulk	51	45
Quebradinho	50	X
Religiosum 8/2	98	X
" 8/14	97	X
Gossypium arboreum L.		
Bani	0	4
Cocanadas	0	6
Goarani	0	0
G. N. Kutchi	4	3
K. 1. bulk	0	4
N. 14	10	8
Thesein cotton	10	8
Verum late	8	8
Gossypium herbaceum L.		
Dharwar 1	0	0
H. 1	0	5
H. 25	5	0
Jayawant	0	0
Russian herbaceum	8	36
Uppam	0	0

X means not sown

These observations denote that under Coimbatore conditions most of the cultures of *Gossypium hirsutum* and *G barbadense* are heavily infected. It was also noticed that in some cases the plants were killed when young. Shoot infection was very common on these. The cultures of *G. arboreum* and *G. herbaceum* exhibited only slight infection (except the Russian *herbaceum*) which consisted mainly of the angular leaf spot phase. Some cultures were completely free from disease under field conditions. Knight (1948) has classified *G. arboreum* and *G. herbaceum* as made up of immune to susceptible types. Among the cultures examined, Russian *herbaceum* exhibited more infection while the others were resistant or immune under local conditions.

SEED TREATMENT AND ITS EFFECTS

Primary infection of black arm is mainly carried through the seeds. Secondary infection is known to occur from the infected plants, plant debris in the soil or from collateral hosts. Driving wind and rain help in the secondary spread of the disease. (Andrews 1936, Brown 1941). Control of black arm by seed treatment has been attempted in several countries with varying measures of success. Seed disinfection with formalin (1: 100) has been found to be very effective in the U. S. S. R. (Verderevski, 1937). Ceresan materially increased the seedling emergence and yield of cotton in various localities in Texas, at the same time reducing the incidence of angular leaf spot (Smith *et al* 1936). Massey (1937) has found that the use of the mercurial dusts Abavit B. ethylmercury pheosphate, ethylmercuryiodide, phenylmercury acetate and several others, gave satisfactory control of black arm in Africa. Seed treatment with mercuric chloride-iodide had resulted in the control of black arm in Sudan (Clouston and Andrews 1938). In some cases, only initial advantage was observed and the disease increased in the later stages of the crop in the treated areas also. But in others improvement in stand and increase in yield have been recorded.

The effect of seed treatment on germination, immediately after treatment and after storage for varying periods and on the incidence of the disease in the early stages of the plant growth were studied. The experiments were conducted in pots and the results are given below. Two hundred seeds were used for each treatment.

TABLE III.

Germination of seeds and incidence of disease (in pot experiments)

Treatment.	Fuzzy seeds percentage of		Delinted seeds percentage of	
	germination	disease incidence upto 35 days	germination	disease incidence upto 35 days
Formalin - 10 minutes		—	74	—
Sown immediately	80			
sown after storing for		1	65	1
15 days	66			
„ 30 „	69	4	79	—
„ 45 „	62	4	67	2
Formalin - 20 minutes				
sown immediately	72	—	74	—
Formalin charcoal dust				
Sown immediately	81	—	91	—
sown after 15 days	71	—	80	—
„ 30 „	75	—	87	—
„ 45 „	75	—	71	—
Agrosan G.	82	—	88	—
Ceresan	80	—	83	—
Control sown immediately	75	20	85	21
sown after 15 days	71	20	63	19
„ 30 „	82	26	86	28
„ 45 „	64	30	66	32

It is seen from the above that seed treatment does not adversely affect the germination of the seeds. The incidence of the disease in the seedlings is effectively prevented by all the treatments. The treated seeds can be stored for over a month without any harm to the seeds.

The effect of seed treatment on the control of the disease in the field sown crop was also studied. The seeds were sown the next day after treatment in randomized plots with six replications. The incidence of the disease was recorded periodically and the results were as shown hereunder.

TABLE IV

The effect of seed treatment under field conditions.

	1940 - 41				1941 - 42			
	Number of plants.	Number of diseased plants after			Number of plants	Number of diseased plants after		
		30 days	45 days	50 days		40 days	45 days	90 days
Formalin steep	423	—	5	68	459	—	8	21
Formalin dust	420	—	4	85	489	2	16	34
Ceresan	429	—	3	86	457	3	18	36
Agrosan G	424	—	1	84	455	2	10	40
Control	424	69	76	152	464	23	71	97

Seed treatment conferred protection from the disease as could be seen from the absence or low incidence of infection in the treated plots, during the first month. But in the course of three months the secondary spread of infection from the neighbouring untreated plots and bulk areas became so widespread that the initial benefit was nullified. It was therefore evident that seed treatment to be of appreciable benefit had to be carried out over the whole area. If sources of secondary infection viz., diseased plants, plant debris from an affected crop etc., were present in the vicinity, the benefits derived from the treatment were lost and no practical advantage resulted.

SELECTION OF RESISTANT CULTURES OF COTTON.

Selection of black arm resistant types of cotton offers a more promising method of controlling the disease. Knight and Clouston (1939, 1941) and Knight (1948) have been engaged in the investigations of black arm resistance of various species of *Gossypium*. They have demonstrated that resistance to black arm is influenced by a number of genes which they have designated as B1, B2, B3, B4. These are present in different species and types of cotton and their effects are described to be additive and linkage has been established between two of them.

Experiments on the selection of resistant cultures after field inoculation with the bacteria were initiated in 1946-47. Sixteen cultures of *G. hirsutum* reported to be promising for other characters were included in the experiments with Co. 3, a susceptible variety as control. From this crop 69 single plants which exhibited a lower incidence than the control were selected and grown during 1947-48. But during that year the incidence of the disease was very low. Consequently no selection on the basis of disease resistance could be made. In 1948-49 black arm infection was satisfactory in the experimental plots. Comparison of the data of infection of angular leaf spot phase and the degree of shoot infection showed that there was positive correlation between the two phases. The data were statistically analysed. Two of the cultures 79-2 and 458-1 exhibited significantly lower incidence of disease compared to the general mean of infection. These two were carried over for further trials. In 1949-50 also the culture 458-1 exhibited significant resistance to black arm while the culture 79-2 was found to segregate. Thus the culture 458-1 has been consistent in its performance under Coimbatore conditions during those seasons and has been found to be resistant to black arm.

We are indebted to the Cotton Specialist and his assistants for all the help rendered in the conduct of the field experiments. Sri K. Narayna Rao of the mycology section helped us in carrying out the experiments and our thanks are due to him.

SUMMARY.

Black arm of cotton has been prevalent in the provice of Madras for several years on *G. hirsutum*. The intensity of infection was observed to be influenced by the rain fall during October to January. Seed treatment with fungicides confers only freedom from primary infection. Most of the varieties of *G. hisutum* and *G. barbadense* are highly susceptible. *G. arboreum* and *G. herbaceum* are mostly resistance or immune. Selection of resistant cultures of *G. hirsutum* is in progress.

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Since sending this for publication the resistance of the culture 458-1 was found to break down during 1950-51. Another culture 2196 (which is the progeny of a cross between *G. hirsutum* and *G. herbaceum* backcrossed with *G. hirsutum*) has exhibited very high resistance in two different tracts. Further observations are being continued.

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EXPLANATION OF PLATE.

a. Intensity of infection of grade 4.

b. Intensity of infection of grade 6.

a

b

a—Intensity of infection of grade 4
b—Intensity of infection of grade 6

BACTERIAL BLIGHT OF COWPEA

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Introduction

Cowpea is grown in India in the *kharif* season. In May, 1945, a destructive bacterial blight of this crop was observed on the Agricultural College Farm, Poona. The results of study of this disease are recorded in the following pages.

E. F. Smith (1920) observing bacterial blight on cowpea and soyabean reported that *Xanthomonas phaseoli* failed to infect cowpea and soyabean. Gardner and Kendrick (1923) have reported a bacterial leaf-spot of cowpea caused by *Pseudomonas vignae*, which has now been found to be synonymous with *Ps. syringae* Van Hall (Clara, 1933). The organism under study is yellow in colour and produces blight but no water-soaked areas on leaves, while *Ps. syringae* is white in colour and invariably produces water-soaked areas. Very recently Burkholder (1944) has described X. *vignicola* producing large fissures and cankers on cowpea and Red Kidney bean. A comparative study has, therefore, been undertaken to investigate its host range, morphology, and physiological and cultural characters.

Description of the Disease

The organism infects all parts above-ground but is mostly confined to the leaves and pods. The symptoms on different parts of the plant are described below :-

Symptoms on leaves.- The disease appears on leaves 6-7 days after inoculation at the earliest or 10-12 days at the latest, as light yellow, irregular to round spots, measuring 4-10 mm., with necrotic brown centres. These are not raised as is the case in leaf-spot of soyabean. No water-soaked areas are produced as in *Ps. syringae* (*Ps. vignae*). These spots increase irregularly until the whole leaf is involved. The centre of the spot is pale brown and surrounded by dark yellow colour which fades off at the periphery. Small veins within the spots become reddish brown, shrivelled and extend into the green of the leaf. This discolouration may extend beyond the margin of the spot. In some cases infection follows along the veins, and the area *around* the vein becomes yellow. These spots may increase and the whole leaf

becomes yellow to brown in 3 weeks. Later such leaves become straw-coloured and remain hanging and drop down at the slightest touch. The plant dies in 5-7 weeks after inoculation (Plate I, Fig. A). In severe cases of blight, the leaves dry up without showing any spots. In nature, infection takes place through the stomate.

SYMPTOMS ON STEMS AND PETIOLES.-No infection occurs on petioles and stems except through wounds.

SYMPTOMS ON PODS.- Dark green, water-soaked spots, 1½ to 2 mm. in size and varying in shape and number (one to many) appear on pods in 6-8 days after inoculation. With age, the pods become yellow and dry, but the water-soaked areas on their surface remain green indefinitely (Plate I, Fig. B). Infection does not extend to the seeds.

ISOLATION

The pathogen was isolated from diseased leaves by the usual poured-plate method using neutral beef or potato dextrose agars; yellow, shining, round colonies begin to appear on the latter medium in 3-4 days at room temperature.

INOCULATION EXPERIMENTS

Cowpea plants produced from healthy surface sterilised seeds were kept in humid condition under bell-jars and inoculated 24 hours later by a suspension of the organism. For further observation, these were removed to a glass-house bench.

Pale yellow spots with necrotic centres appear in 5-6 days after inoculation. These spots increase in size and number. In severe cases of blight, the leaves wilt and the plants die in 5-7 weeks after incoulation. The control plants remained healthy. The pathogen was reisolated from the infected leaves.

Inoculation of leaves by punctures and by slits on petioles and stems turned brown in 8-10 days and later became black. The symptoms appeared earlier in wounded plants.

INOCULATION OF COWPEA PODS.- Healthy cowpea plants with 8 healthy pods (4 punctured and 4 unpunctured), seven to eight days after inoculation showed several small, water-soaked, dark green spots which persisted even after the pods had dried up.

MORPHOLOGY OF THE COWPEA ORGANISM

The organism is a short rod with rounded ends, occurring singly, rarely in pairs but never in chains. In cultures on potato-dextrose agar varying in age from a few hours to three weeks, the organism, on an average, measures 1.74 μ (1.2-2.4) x 0.86 μ (0.6-1.1). Motile with single polar flagellum, gram-negative and not acid fast: distinct capsule but no spore.

CULTURAL CHARACTERS

In potato-dextrose agar plates, the organism in 5 days forms smooth, round, glistening, butyrous. odourless, convex, pinard yellow (Ridgway) colonies with entire margins and measuring 0.2 to 0.8 cm. In nutrient agar plates, on the other hand, the colonies are slow growing, poor, smooth, round glistening, odourless, light cadmium (Ridgway) with entire margins and measure 0.1 to 0.3 cm. In nutrient broth, a slightly cloudy growth with a formation of ring, but no pellicle, and sediment occurs without browning the medium. Yellow, copious, slimy and glistening growth occurs in 5 days on potato cylinders. Litmus in milk is reduced completely in 6 days without formation of tyrosine crystals. Casein in plain milk is digested 6 days with some sediment and the medium becomes acidic showing the production of the enzyme erepsin. The pathogen is a strict aerobe. The optimum temperature for its growth lies between 25° and 32°C, growth ceasing at 6° and 42°C. The thermal death point is about 50°C.

BIOCHEMICAL REACTIONS

Gelatin liquefaction proceeds rapidly. Hydrogen sulphide tests made with strips of filter paper impregnated with lead acetate solution showed positive reaction. Indol formation is lacking. Nitrites and ammonia from peptone or potassium nitrate are not produced. Löeffler's blood serum is not liquefied. In Cohn's, Uschinsky's, Koser's uric acid and citrate media, the growth is inhibited. Absence of growth in the latter two media clearly indicates that the pathogen is not able to utilise carbon and nitrogen from complex carbon and nitrogen compounds. This was further supported by the inability of the organism to grow in asparagin medium. Broth containing 3 per cent sodium chloride allowed good growth of the organism while 4 per cent inhibited it completely. No browning was produced in synthetic carbohydrate medium containing tyrosine. M. R. and V. P. tests are negative.

The cowpea pathogen grows well in several synthetic mediua containing dextrose, lactose, raffinose, glucose, sucrose, maltose, galactose, l-arabinose, d-arabinose, mannitol, xylose and levulose with production of acid in the first

nine and no growth in salicin, rhamnose and glycerol. Gas was absent in all. Starch is hydrolised. Maximum growth occurs at ph 7. The organism lives for 154 days at 13°C., 100 days at 0°C. while it cannot withstand desiccation for more than 7 days.

HOST-RANGE

From several inoculation trials made under the most optimum conditions, it was found that the cowpea organism is pathogenic only to *Vigna catjang*, *V. sinensis*, *V. sesquipedalis*, *Phaseolus vulgaris* var. White Refugee, Dwarf Horticultural, U. S. No. 5 Refugee Wax, Red Kidney, Idaho Refugee, Yellow seeded, Long fellow, Full Measure and Giant Stimulus Green Pod while it failed to infect *P. vulgaris* var. Refugee Wax, *P. lunatus*, *P. aconitifolius*, *P. coccineus* (Runner Bean var. Painted Wax), *P. aureus*, *P. mungo*, *Pisum sativum*, *Arachis hypogaea*, *Cajanus cajan*, *Cicer arietinum*, *Crotolaria juncea*, *Cyamopsis psoraloides*, *Dolichos lablab*, *Lathyrus odoratus*, *L. sativus*, *Soja max*, *Trigonella foenum-graecum* and *Ipomoea muricata*.

From the data presented above, it is evident that the cowpea pathogen is quite different from X. *phaseoli* and its varieties (Burkholder 1930 and Uppal, Patel and Nikam 1946) as the former is pathogenic on species of *Vigna* and *P. vulgaris* only. Burkholder (1944) has, however, described a disease causing cankers on the stem of cowpea and blight of the common bean from the specimens sent to him by Dunlop in 1942. Though X. *vignicola* attacks *Vigna* spp, and *P. vulgaris* as the cowpea organism does, the data presented by Burkholder and the study of the cowpea organism show the following differences;—

(1) The cowpea organism differs from X. *vignicola* in its relation to growth in xylose and levulose, in which the latter fails to grow.

(2) The cowpea organism not only grows well in l-arabinose but produces acid, while X. *vignicola* is not reported to grow in this sugar.

(3) The cowpea organism does not produce tyrosine crystals, while X. *vignicola* does.

(4) The cowpea organism does not produce brownish purple colour in plain milk, while X. *vignicola* does.

(5) Further, Burkholder (1944) has not noted the behaviour of X. *vignicola* for the following tests:—

i. staining for capsule.

ii. growth in the media, viz., Uschinsky's, Cohn's, uric acid and sodium citrate,

iii. production of ammonia and acetyl methyl carbinol

iv. liquefaction of Loeffler's blood serum,

v. digestion of casein,

vi. fermentation of mannitol, glucose, d-arabinose and

vii. pathogenicity on *Dolichos lablab* and *P. lunatus*

In the absence of information on X. *vignicola* on the points mentioned above, it is considered advisable to assign the same name to the cowpea pathogen.

SUMMARY

Bacterial blight is a serious disease of cowpeas grown on the Agricultural College Farm, Poona. The prominent symptoms are the production of spots on the leaves and blight of the plant, resulting in its ultimate death. Water-soaked areas are observed only on pods.

The organism was isolated from spots on the leaves and its pathogenicity proved. The cowpea organism resembles *Ps. syringae* in having *Vigna* spp. as common hosts, but the former organism is yellowish in colour, encapsulated, polar flagellate while the latter is white, non-capsulated with tufts of polar flagella besides infecting several unrelated hosts. X. *vignicola* differs from the cowpea organism in some cultural and physiological characters although the host plants as reported by Burkholder (1944) are identical. For these reasons, the cowpea pathogen is tentatively considered similar to X. *vignicola*.

The writers are greatly indebted to Dr. B. N. Uppal, Director of Agriculture, B. S., Poona, for valuable suggestions made during the course of this investigation.

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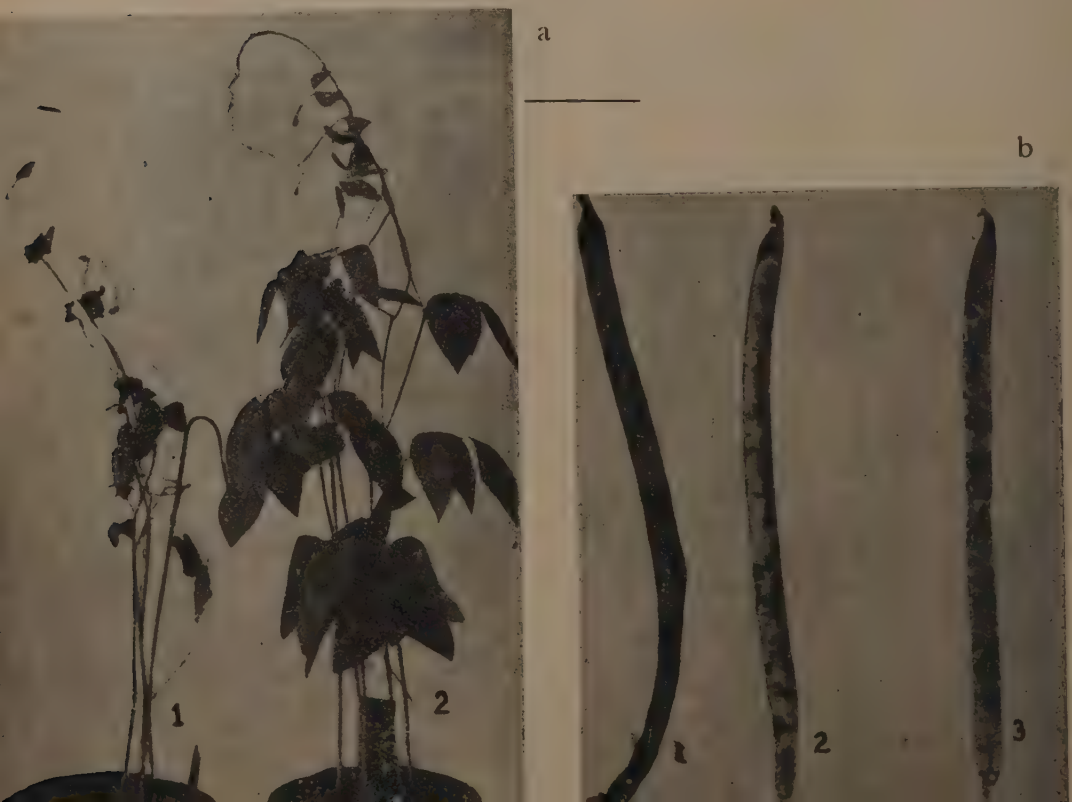
Fig. A. 1. Blighted plants. Time 7 weeks. 2. Healthy plants.
Fig. B. 2-3. Dark green, water-soaked spots on infected pods. Time 6-8 days.
1. Healthy pod.



NOTES ON SOME SPECIES OF *CORTICIUM* AND *PELLICULARIA*

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The genus *Corticium* was founded by Persoon in 1794, but since the nomenclature of the *Agaricales* or *Hymenomycetales* starts with Fries, the generic name dates only from his Epicrisis, 1836-38. According to Burt (1926), *Corticium* includes *Gloeocystidium* v. Höhnel and Litschauer. At present according to Jackson (1948) it comprises several unrelated groups of species separable into *Ceratobasidium* Rogers, *Pellicularia* Cooke (*Botryobasidium* Donk), and *Trechispora* Karst. The writer (1949) has shown that *Pellicularia koleroga* Cooke is not a valid name, and that it should be charged to *Botryobasidium koleroga* (Cooke) Venkatarayan. Rogers (1943) admits that *Pellicularia koleroga* is a good *Botryobasidium*. The differences between *Corticium* and *Botryobasidium* do not appear to be great. *Botryobasidium* Donk was described in 1931 for certain species of *Corticium* corresponding to those of the section *Botryodea* of Bourdot and Galzin. According to Linder (1940) *Botryobasidium* is intermediate in its relationship between *Ceratobasidium* and *Corticium*, differing only in the size of the sterigmata in proportion to the basidium. It contains forms whose basidiospores germinate by repetition, i. e. by the formation of secondary spores, and those which germinate by a normal germ tube. Since the genus *Pellicularia* is based on *Pellicularia koleroga* as type, the name of the genus also must be changed to *Botryobasidium*. A number of species of *Hypochnus*, *Corticium* and *Peniophora* have been brought under *Pellicularia* Cooke *sensu* Rogers. *Hypochnus* Fries (1874) was emended by Karsten in 1881, omitting the forms related to *Corticium*. According to the Nomenclature Committee of the British Mycological Society (1939) *Hypochnus* is an ambiguous name and is not valid. *Peniophora* like *Corticium*, contains a number of unrelated forms, and differs from it only in the presence of cystidia.

Dastur (1940) described a new *Corticium* on orange (*Citrus aurantium*) stem under the name *Corticium album*. Mundkur (1940) showed that this fungus was a later homonym of *Corticium album* Britz. (1897) and hence untenable; he also pointed out that as the new species lacked a Latin diagnosis it was a *nomen nudum*. Rogers (1943) in discussing this fungus suggested that it appeared highly probable that it is a member of the genus *Pellicularia*. Reexamining the type specimen and the slides of this fungus, Dastur (1946) found it to agree with *Pellicularia* and, not finding any resemblance to *Pellicularia flavescens* (Bon.) Rogers as suggested by Rogers, named it *Pellicularia alba* n. sp. The name of this fungus should be changed to *Botryobasidium album* (Dastur) comb. nov.

Dastur (1941) described *Corticium salmonicolor* B. and Br. on orange trees (*Citrus aurantium*) in the Central provinces. He (1946) again examined the specimens of this fungus in the *Herb. Crypt. Ind. Orient.* New Delhi on *Hevea brasiliensis* collected from Travancore in September 1909 and from Burma in July 1915, *Citrus* sp. collected from Coorg in September 1942, and *Acacia arabica* collected from the Punjab in August 1944, and found all the fungi to be identical, and to agree with *Pellicularia* on which account he renamed it *Pellicularia salmonicolor* (B. and Br.). *Cortium salmonicolor* B. and Br. (syn. *Necator decretus* Massee) was described in 1873. Petch (1912) says that this fungus is synonymous with *Corticium javanicum* A. Zimm. (1901) on *Coffea arabica* and *Coffea liberica* in Java. This is not *Corticium javanicum* (P. Henn.) Sacc. et Syd. (1902) which is a synonym of *Aleurodiscus javanicus* P. Henn (1899). Petch (1910) says this is identical with *Corticium peradeniae* B. and Br. and hence is changed to *Aleurodiscus peradeniyae* (B. and Br.) v. Höhnel. *Corticium zimmermanni* Sacc. et Syd. (1902) is synonymous with *Corticium javanicum* A. Zimm., having been described under an error. Petch (1923) says *Corticium lilacino-fuscum* B. and C. causing the pink disease of *Cacao* in the West Indies is a synonym of *Corticium salmonicolor*. The original type specimen of *Corticium salmonicolor* B. and Br. is at Kew, and until this is examined and found to agree with this description any name suggested can only be provisional. This fungus can therefore tentatively be called *Botryobasidium salmonicolor* (B. and Br.) comb. nov.

West (1947) proposed to name the basidial stage of *Sclerotium rolfsii* on the climbing fig *(Ficus pumila* L.*) Pellicularia rolfsii* (Sacc.) nov. comb., because the perfect state resembles *Corticium rolfsii* (Sacc.) Curzi. Mundkur (1934) obtained the perfect state of this fungus in cultures from cotton, betelvine, potato, and sugarcane. The writer (1937) and Venkatakrishnaiya (1946) reported the perfect state of *Sclerotium rolfsii* in cultures of the fungus from pseudo-stems of plantain (*Musa sapientum*) causing a disease locally known as *taragumari roga*. This fungus is now proposed to be renamed *Botryobasidium rolfsii* (Sacc.) comb. nov.

Ramakrishnan and Ramakrishnan (1948) have found a banded leaf blight of arrowroot (*Maranta arundinacea* to be caused by *Pellicularia filamentosa* (Pat.) Rogers. Rogers' (1943) description of *Pellicularia filamentosa* with sterigmata as blunt knobs later becoming horn-shaped, and spores 'flattened on the inside, a little broadest below the middle, truncate-apiculate', and with a little larger dimensions for them than those of the *Maranta* organism, seems to suggest that these two fungi may not be identical. Ramakrishnan and Ramakrishnan (1948) seem to have got mixed up with *Pellicularia filamentosa (Corticium vagum* sensu Burt*)*, and *Pellicularia vaga (Corticium vagum* Berk. and Curt.*)*. Their refere-

nce to *Corticium vagum* Berk. and Curt. as a synonym of *Pellicularia filamentosa* is incorrect. The *Maranta* fungus is obviously not *Pellicularia vaga* which has 4 or 5, mostly 6-8 stout, divergent, recurved sterigmata. It is not also *Pellicularia koleroga* (*Corticium koleroga*), because this species does not form the kind of sclerotia described in pure cultures West's (1947) description of basidiospores of *Pellicularia rolfsii* n. sp., here changed to *Botryobasidium rolfsii* (Sacc.) n. comb. (*Corticium rolfsii* Curzi=*Sclerotium rolfsii* Sacc.), seems to tally with that of the basidiospores of the *Maranta* fungus.

As suggested by Butler (1918), the fungus causing banded sclerotial disease of sugarcane resembles *Hypochnus solani* and *Corticium koleroga* and is thought in Japan to be the same as *Hypochnus sasakii*. Butler also states that the fungus from *Maranta*, rice and three wild grasses can infect sugarcane. Ramakrishnan and Ramakrishnan (1948) seem to agree with Ryker and Wei that *Hypochnus sasakii* closely resembles *Corticium (Rhizoctonia) solani*. Rogers has not described sclerotia for *Pellicularia filamentosa* as apart from the sclerotial stages, *Rhizoctonia solani* and *Rhizoctonia microsclerotia* which are synonymous with his fungus. *Hypochnus filamentosus* Pat. and *Hypochnus solani* Prill. and Del. are similar according to Rogers, the differences being only in the presence or absence of sclerotia, their size, time and place of formation, characters not to be relied upon. But according to Matsumoto *Hypochnus sasakii* and *Corticium solani* are distinct fungi. Matsumoto and Yamamoto (1935) have subsequently shown that *Hypochnus sasakii* agrees with *Corticium koleroga*.

Ramakrishnan and Ramakrishnan (1948) have found sclerotia in *Pellicularia filamentosa*, small and buff to tan coloured on the lower surface of the leaf. In cultures they obtained white cushiony sclerotioid bodies and big chocolate coloured sclerotia with a velvetty surface, with one or two drops of fluid on the surface. These compare very well with the description of the sclerotia of *Corticium centrifugum* on *Delphinium* plants in Victoria by Balfe (1935). According to Waterston (1947), Ogilvie in Bermuda intercepted *Corticium rolfsii* (found only in the sclerotial stage, *Sclerotium rolfsii* Sacc, and *Sclerotium delphinii* Welch) on *Maranta arundinacea* L. imported from St. Vincent, B. W. I., in 1927. Nowell (1923) does not refer to this disease on arrowroot, although he devotes a special section to this crop, and another to diseases caused by *Sclerotium rolfsii*, a widely distributed soil fungus in the Lesser Antilles. The disease must have appeared in St. Vincent some time between 1923 and 1927.

Sclerotium rolfsii includes more than one *Sclerotium* distributed in different groups. According to Nakata (1926), Sawada in 1919 found the perfect stage

of *Sclerotium rolfsii* from a diseased camphor tree to be *Hypochnus centrifugus* (Lev.) Tul. [*Corticium centrifugum (*Lev.*)* Bres.] In 1925 Nakata obtained a perfect stage from two strains of *Sclerotium rolfsii* from Japan and one from America which he referred to *Corticium centrifugum*, different from *Corticium solani (Corticium cucumeris)* in colour of mycelium and activity of sclerotium formation. Goto (1930) also refers the perfect stages of *Sclerotium rolfsii* from sugarcane and other hosts to *Corticium centrifugum*. On the authority of Miss Westerdijk, Curzi (1931) says that *Sclerotium rolfsii* of Nakata and Goto corresponds to *Sclerotium delphinii* Welch. Curzi (1932) divides *Sclerotium rolfsii*,, into three distinct groups on the shape and size of the sclerotia, *Sclerotium rolfsii* original strain, *Sclerotium centrifugum* n. comb., and *Sclerotium delphinii* Welch. Some more clarification is necessary to settle the identity of the fungus on *Maranta arundinacea*.

I am indebted to Dr. B. B. Mundkur, Deputy Director, Plant Diseases, Ministry of Agriculture, Government of India, for advice and for a critical reading of the manuscript.

SUMMARY

The species *Pellicularia koleroga* Cooke, being invalid, the generic name *Pellicularia* Cooke is proposed to be changed to *Botryobasidium* Donk. *Pellicularia alba* Dast. is changed to *Botryobasidium album* (Dastur) comb. nov, *Corticium salmonicolor* B. and Br. to *Botryobasidium salmonicolor* (B. and Br.) comb. nov., and *Pellicularia rolfsii* [*Corticium rolfsii* (Sacc.) Curzi = *Sclerotium rolfsii* Sacc.] to *Botryobasidium rolfsii* (Sacc.) comb. nov.. The identity of *Pellicularia filamentosa* (Pat.) Rogers causing a banded leaf blight of arrowroot *(Maranta arundinacea)* is doubted, and a comparison is made between this fungus and *Botryobasidium rolfsii* (Sacc.) comb. nov.

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LEAF SPOT DISEASE OF OATS AND ITS CONTROL

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I. INTRODUCTION

In India a systematic study of *Helminthosporium* species occurring on various graminaceous hosts other than oats was made by Mitra (1931, 1934). Butler (1918), however, had recorded earlier the occurrence of *Helminthosporium avenae* Eidam on oats.

The disease is one of the most serious attacking oats and was first described in 1819 by Briosi and Cavara in Italy and subsequently reported from other countries by different workers. Ito and Kuribayashi (1931) reported the presence of the perithecial stage of the fungus in Japan and showed it to belong to *Pyrenophora avenae* Ito and Kuribay. *Helminthosporium victoriae* M. & M, reported to occur in U.S.A. by Meehan and Murphy (1946) on oat varieties derived from crosses with Victoria, has not been found in India so far.

In 1947-48, a leaf spot disease was found to be very severe in the oat crop raised in the experimental areas of this Institute. Approximately eighty percent of the crop sown late in November on the Agricultural Sub-station Karnal was also found to be heavily infected with the disease.

The disease, which affects the leaves, is responsible for considerable reduction in the yield of grain. In view of the importance of the crop the investigation of the disease was undertaken in order to devise control measures.

In the primary phase of the disease, the seedlings are killed either before or shortly after emergence, or show severe striping of the first and second leaves. Such seedlings die during early stages of development or, if they survive, produce weak plants. The conidia produced on the seedlings are responsible for secondary infection resulting in the formation of leaf spots and infection of the seed.

II. MATERIAL AND METHOD

The fungus was isolated from leaves of cultivated oats, *Avena sativa* L. Since profuse sporulation was not obtained in culture, the infected leaves were surface sterilized with ·01% mercuric chloride solution, washed in sterile water and kept under aseptic conditions. With this method, sporulation occurred in about 24 to 48 hours. The organism was purified by single spore culture.

N. P. 2, a variety of oats found heavily infected in the field, was used for inoculation. In all the experiments, unless otherwise stated, naturally infected seeds from the previous year's crop was utilized.

III. EXPERIMENTAL

A. **Pathogenicity.**

1. INOCULATION OF LEAVES.-Seedlings raised from seeds which had been previously treated with Agrosan GN were sprayed with water and placed inside a moist chamber for about 4-6 hours before and 24 hours after inoculation. The results show that 100 percent infection occurs whether the inoculum is applied to the upper or the lower surface of the leaf; also that wounds are not a prerequisite to infection which can be obtained by the use of spores as well as the mycelium. The infection appears in 2 days when spores are used and in 5 days when mycelium is used as inoculum.

2. SEED INFECTION– Oats seeds obtained from plants which appeared to be healthy were infected by placing them in a suspension of the fungal mycelium in sterile water under vacuum. The seeds so infected were sown in pots containing sterilized soil. Seed that had not been artificially infected as above was sown to serve as control. In the case of seeds that were infected, the emergence of seedlings was 75 percent as compared to 97.5 percent in the controls; while the percentage of leaf stripe in the former was 66.7, it was only 5.7 in the controls The slight infection in the control shows that the seed used for these experiments was not obtained only from healthy plants and that some mixture had occurred.

B. **Morphology and Physiology :-**The conidiophores generally occur singly; rarely in groups of two or three. They are thick walled and brown in colour; the basal cell is slightly swollen, affording a firm point of attachment to the epidermis. In certain cases branching of the conidiophore may occur. Their length and breadth vary from 126 to 199. 5μ and 8.4 to 10.5μ, respectively. They have characteristic knee-shaped bends, each marking the point of attachment of a conidium.

The conidia are more or less cylindrical with rounded ends, tapering slightly at the terminal cell. The basal cell is hemispherical with a well-marked hilum. The conidia in their early stages are sub-hyaline but later turn olivaceous green. They measure 29.4-117.6 x 14.7-16.8μ, the average being 100 x 15.8μ. The number of septa varies from one to seven, 4 to 5 being common.

Temperatures between 10° and 30°C are suitable for the germination of conidia but the optimum lies between 18°-25°C. The fungus, however, grows best between 18° and 24°C. on Brown's synthetic and potato dextrose agar. The fungus can tolerate a wide range of pH from 3 to 10, but optimum growth is obtained at pH 6.0.

C. **Host range** :-Leaves of wheat, barley, rye and oat were inoculated with the spores of the fungus. It was observed that only leaves of oat took 100 percent infection, whereas others proved to be resistant. These findings were repeatedly confirmed and agree with those of Rathschlag (1930) and Turner and Millard (1930) showing thereby that the causal organism is *Helminthosporium avenae.*

Phalaris minor Retz., an annual grass has been observed infected for the first time with this disease under natural conditions along with oats at Karnal, Nagina and Delhi. *Avena fatua* another wild grass, growing near cultivated oats, was also found infected. Isolations made from *Phalaris minor* as well as *Avena fatua* from all the collections resembled *Helminthosporium avenae* and infected leaves of *Avena sativa.*

Cross inoculation with spores of *H. avenae* obtained from cultivated oats also successfully infected leaves of *Phalaris minor* and *Avena fatua.*

Both leaf and seed inoculations of oat varieties N. P. 1, N. P. 2, Victory, Richland, Joenette, Minrus, and Victoria proved Victoria to be susceptible to *H. victoriae* which also infects barley. Basal stem rot and root rot symptoms characteristic of *H. victoriae* were not observed in our experiments.

The fungus under investigation was compared with a culture of *H. victoriae* and the results are presented in table 1.

TABLE I. *Characteristics of Helminthosporium avenae and H. victoriae compared*

	H. avenae	*H. victoriae*
Conidiophores	126-199. 5 x 8. 4-10. 5 μ	60-280 x 5.8-10 μ
Conidia		
No. of septa	1 - 7	4 - 11
Length	29.4 - 117.6 μ	40 - 130 μ
Breadth	14.7 - 16.8 μ	11 - 25 μ
Colour	Sub-hyaline to olivaceous green with the basal and terminal cell frequently colourless.	fuligenous to dark olivaceous
Pathogenic to	Oats except variety Victoria; not to barley.	Oats including variety Victoria, also to barley.
Germination of spore	from terminal as well as intermediate cells	from polar cells only.

D. **Effect of variation of sowing time on disease incidence**— A preliminary experiment was carried out by sowing artificially infected oat seed in pots at regular intervals from September to March during 1948-49. Records of soil temperature were maintained by taking these observations at regular intervals throughout the experimental period. Each test was concluded when the second leaf in the seedlings had grown equal to the first as the tests conducted earlier had indicated that maximum incidence occurs by this time.

As expected, the experimental period in each sowing varied according to the season depending on the prevailing temperature. During January, the seedlings took 33 days to attain the required stage of growth, whereas this period was reduced to half during September, October and March. The observations made in this connection are given in table II.

TABLE II. *Effect of date of sowing on incidence of the disease*

Date of sowing in pots	Mean soil Temperature °C	No. of seeds sown	Emergence	No. infected	Percent infection
15 September	22.3	120	118	15	12.7
1 October	20.8	120	118	20	16.1
15 October	16.0	120	118	26	22.0
1 November	14.6	120	116	35	30.1
15 November	13.0	120	115	43	37.3
1 December	12.5	120	113	49	43.4
15 December	12.0	120	113	50	44.2
1 January	9.6	120	112	63	56.3
15 January	14.3	120	116	38	32.7
1 February	15.1	120	118	31	26.3
15 February	15.1	120	118	28	24.5
1 March	23.0	120	118	14	11.8

The data show that the disease incidence in sowings made on 1st March, 15th September and 1st October is the lowest and varies from 11.1 to 16.1 percent. Maximum infection of 56.3 percent is observed in the sowing of 1st January. The mean temperatures for periods of minimum and maximum disease incidence were 20.8°–23.0°C and 9.6°C. respectively.

During 1949-50 a similar experiment was laid out in the field. Six sowings were done from 18th October to 28th December at regular intervals. On each date seed that had been previously infected was sown in one plot whereas the other plot was seeded with healthy seeds treated with Agrosan GN (2:1000) to

ensure freedom from disease to serve as a check. The data of such an experiment are furnished in table III.

TABLE III. *Variation in date of sowing as influencing the incidence of the disease*

Date of sowing	Control plot					Diseased plot				
	No. of seeds		No. of seedlings infected	No. of infected seedlings died	% of infection	No. of seeds		No of seedlings infected	No. of infected seedlings died	% of infection
	sown	germinated				sown	germinated			
18-10-49	420	399	0	0	0	420	398	1	0	.25
28-10-49	420	392	0	0	0	420	394	32	5	8
9-10-49	420	385	0	0	0	420	389	90	11	23
19-10-49	420	385	0	0	0	420	384	172	16	45
30-11-49	420	383	0	0	0	420	384	171	17	45
28-12-49	420	380	0	0	0	420	379	172	17	45

The results indicate that the disease incidence varies according to the time of sowing and that the temperatures prevailing during such period determine whether the disease would occur in a severe form. When sowings are done during the month of October the amount of primary infection is negligible. Large scale tests in this direction, however, require to be conducted.

E. Effect of seed treatment.

It is known that the fungus causing leaf spot of oats oversummers by means of conidia adhering to the grain and by mycelium existing between the paleae and kernel. According to Muskett (1938) organo-mercuric fungicides are most effective in the control of this disease. Fungicidal seed dressing with Agrosan GN, Ceresan, Spergon and Uspulam was, therefore, tried with a view to control the disease. The dosage was 2.5 : 1000 in the case of first three fungicides and 0.25 percent solution of Uspulum. Untreated seed was sown to serve as control. Though the experiment was conducted on a small scale in pots, seed treatment was found to improve the emergence and stand of seedlings and also to reduce primary infection in all cases. Agrosan GN and Ceresan were observed to be more effeciive than Spergon or Uspulum.

The efficacy of Agrosan GN in disease control has also been apparent in this year's tests.

The data showing the effect of fungicides are furnished in table IV.

TABLE IV. *Effect of fungicidal seed treatment on emergence and disease incidence*

Treatment	No. of seeds sown	Percent emergence	Percent leaf stripe
Untreated control	160	66.2	20.7
Agrosan GN	160	94.4	0
Ceresan	160	88.9	0
Spergon	160	85.6	5.2
Uspulum	160	78.1	0

IV. DISCUSSION

Helminthosporium avenae has been shown to be the cause of leaf spot of oats in India. It has also been shown that soil temperature is the chief factor governing the incidence of primary leaf stripe. These results agree with those obtained by O'Brien and Prentice (1930), Dennis(1933) and Muskett (1937) who have shown that the incidence of the disease is greater at lower than at higher temperatures. Leukel, Dickson and Johnson (1929) also consider that low soil temperature is of primary importance in the case of barley leaf stripe. Smith (1929) remarks that "Winter-sown barley in Britain is particularly liable to be attacked". It is natural, therefore, to expect the primary phase of the disease to be more severe in colder regions than those that are warmer. Quite a large number of seedlings may escape infection, even if raised from infected seed, provided environment is favourable for a rapid germination of the seed and quick development of the seedlings. It is for that reason that the incidence of the disease can be reduced considerably by sowing the oat crop early in India, when the temperature is high.

Two wild grasses, *Phalaris minor* and *Avena fatua* have been found to be collateral hosts Also infected self-sown plants of oat have been observed in the month of August i. e. 2-3 months before the oat crop is normally sown. For a successful control of the disease, therefore, it is necessary to eradicate the two wild grasses known to be collateral hosts, as well as the self-sown plants, at least in the immediate neighbourhood of the crop, in addition to seed treatment for which Agrosan G N and Ceresan have been found to be effective.

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during the course of these investigations and for kindly correcting the manuscript.

V. SUMMARY

1. *Helminthosporium avenae* has been shown to be the causal organism to which Victoria variety of oats is resistant. Two wild grasses *Phalaris minor* and *Avena fatua* act as collateral hosts.

2. Sowing the crop early, i. e. during October, reduces primary infection. Based on experimental results, it is suggested that seed treatment with Agrosan G N or Ceresan, sowing the crop early and eradication of wild collateral hosts and selfsown oat plants should control the disease.

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BACTERIAL LEAF-SPOT OF CHILLIES

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Introduction

Although chillies form a part of daily seasoning of food of both the rich and the poor all over India, they are not indigenous to India but seem to have been introduced from South America and are now cultivated all over India. The area occupied by this crop in Bombay State alone comes to one hundred twenty five thousand acres. The cultivation of this crop is limited to black to medium black soils. A bacterial leaf-spot on this crop was noticed for the first time in India on the Agricultural College Farm. Poona, in August 1948. The pathogen was isolated and studied in detail.

Symptoms

Leaves.—The pathogen produces a number of small spots which as they develop become round to irregularly round in shape (1 mm.) with raised water-soaked borders on the lower surface and a pale white centre with a slight depression on the upper surface. Leaves curl when edges and veins are infected. A few spots may coalesce to form irregular lesions. The raised borders due to bacterial exudation in old spots become brown in colour on both the surfaces. Severely affected leaves become yellow and drop off prematurely. Infection of leaf-petiole is common.

Stems.—During rainy season, the infection extends to tender parts of stems producing vertical light brown scars which under favourable weather conditions develop into longitudinal cracks measuring sometimes 4 cm. In the case of very young plants, the entire stem gets girdled due to infection resulting in wilt.

Fruit.—On fruit, the disease is characterised by round, raised, water-soaked spots with a pale yellow border. These spots later become brown with a depression in the centre where bacterial ooze in the form of small, shining beads is often seen.

Morphology

The organism is a short rod, gram-negative, single, motile by a polar flagellum, not-acid fast, non-sporing, a strict aerobe and measures 1.7 x 0.9 μ.

Cultural and Physiological Characters

On potato dextrose agar plates, colonies are smooth, glistening, raised,

measuring 1 to 1.2 cm. after 4 days, colour apricot yellow (Ridgway); on potato dextrose agar slants, growth copious, raised, filiform, opalescent, consistency butyrous, colour amber yellow (Ridgway); on potato cylinders, growth copious, raised, shining, flowing and covering the entire surface in 4 days, colour of the cylinders changing to dark-brown; on nutrient agar plates, growth slow and poor, flat, smooth, glistening, convex, round with fringed margins, measuring 1 cm. after 4 days, inner 9 mm. of the colony lemon-chrome in colour (Ridgway) while the outer 1 mm. periphery of the colony is pale white; in nutrient broth, good cloudy growth in 24 hours; slight clearing of milk in 4 days; litmus almost reduced in 8 days; gelatin liquefied; starch attacked; produces acid but no gas from dextrose, lactose, sucrose and nitrates not reduced; ammonia produced; indol not produced; Loeffler's blood serum slowly liquefied in 8 days; M.R.,V.P. tests negative; thermal death point about 51°C.

TRANSMISSON OF THE DISEASE

According to Higgins (1922), appearance of the disease in seed-beds where peppers had never been grown before was a conclusive evidence that seed carries the infection. Gardner and Kendrick (1923) showed that the organism causing tomato canker could survive dessication on tomato seed for 16½ months In order to find whether the chillie organism is seed-borne, a fruit of giant chillie was artificially infected and its seeds collected. After 6 months, the seeds were planted in sterilised soil in 6 inch pots, when all the seedlings showed the characteristic bacterial leaf-spot confirming that seed is an important source of primary infection even under Indian conditions. It may be pointed out here that seedlings are always grown in nursery where seedling infection may result from the use of contaminated seed. The disease spreads in the nursery and is further disseminated with infected transplants. Treating the suspected seed with mercuric bichloride (1:1000) for 2-5 minutes should prove effective.

HOST RANGE

Several hosts including chillies (2 varieties) were lightly wounded with multiple needles and kept under moist chambers before and after inoculation. Characteristic symptoms of the disease became visible on chillie and tomato leaves after 6 days. The organism could produce canker on unripe tomato fruit as described by Gardner and Kendrick (1921) but failed to infect cabbage, radish, egg plant, beet, lettuce, french beans, *Datura* sp and sweet peas.

IDENTITY OF THE ORGANISM

It is evident from the symptoms and morphological, cultural and physiological characters that the organism causing bacterial leaf-spot of chillie at

Poona is similar to the one on pepper from Georgia described by Higgins (1922) who showed that it was identical to *Bacterium vesicatorium* Doidge causing tomato canker described by Doidge (1921) in South Africa but did not decide upon the exact nomenclature of the pepper organism. Gardner and Kendrick (1921) described a bacterial spot of tomato in Indiana and named the organism *B. exitiosum*, not knowing the paper by Doidge (1921). These authors (1923) later compared the three organisms *viz* (1) *B. vesicatorium*, (2) tomato organism from Indiana and (3) pepper organism of Higgins and found them to be practically identical. Moreover, the three organisms proved infectious to tomato and successful inoculation of pepper leaves and fruit was obtained with tomato strain from Indiana. According to priority, *B. vesicatorium* Doidge was retained. The authors of the present article got successful infection of unripe tomato fruits with the chillie organism and are of opinion that the organism under study is *Xanthomonas vesicatorium* (Doidge) Dowson (1943) which must have been introduced in India along with seeds.

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SUMMARY

A bacterial leaf-spot of chillies has been noticed for the first time in India on the Agricultural College Farm, Poona, in August, 1948.

The organism is identical with *X. vesicatorium* (Doidge) Dowson causing bacterial leaf-spot of pepper and tomato fruit canker in Georgia and Indiana, respectively.

It is affirmed that the disease is seed-borne for which a remedial measure is suggested.

The organism readily infects leaves and unripe wounded chillie and it is inferred that the disease was introduced in India along with seeds.

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RELATION OF FOOD TO OOSPORE PRODUCTION IN PHYTOPHTHORA

M. K. Desai

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Reports of species of *Phytophthora* ceasing to form oospores altogether or producing them sparingly after once abundantly forming them have been made by various investigators. Thus, Rosenbaum (1917) noted that *Phytophthora arecae* (Coleman) Pethybridge formed few or no oospores though it had produced them in abundance once on oat meal agar. Similar loss in the formation of oospores was noted by Leonian (1925) in *P. capsici* Leonian on malt extract agar, in *P. cactorum* (Lembrt and Colin) Schroet, on artificial media and in culture No. 139 of Carl Hartley's and Reinking's collection of tropical *Phytophthoras*. Narsimhan (1930) records the loss of oospore formation in *P. parasitica* Dastur and in *P. meadii* McRae. Tucker (1931) on the other hand, showed that *P. capsici* and *P. cactorum* could form oospores in abundance on various media.

Various suggestions have been made to explain this phenomenon. For instance, Leonian in his early publication (1925) suggested that this might be due to continued culturing on artificial media. In a later publication (1931) he ascribed this to apparent sexual neutrality and stated that "Sexuality is not a definitely fixed character but that it may depend on both internal and external environmental factors as well as on the introduction of the opposite strains". He further suggested that one or the other strain might be left behind while transferring and it would not be possible to carry them together in pure culture for a long time. Clinton (1908) on the other hand, suggested that the absence of oospore formation in some culture of *P. infestans* (Mont.) de Bary might be due to deterioration of the male mycelium. A similar deterioration of the male mycelium had also been noted in *P. parasitica* and in *P. meadii* by Narsimhan (1930.)

While working with different spp. of *Phytophthora* in relation to "Koleroga disease" of areca nut, it was noticed that a sp. of *Phytophthora* freshly isolated from the leaves of *Artocarpus integrifolia* L. in 1942 and *P. arecae* (+&– or Tyagli and Nilekani strains) (Uppal and Desai 1939) freshly isolated from areca nut in 1943 formed abundant oospores on oat meal agar but lost this capacity of oospore formation when continuously cultured for two to three years. Experiments were, therefore, undertaken to determine whether this loss of oospore formation in *Phytophthora* might indicate a possible food relationship. These cultures were then transferred to French bean agar or passed through their respective hosts and when mated, showed abundant production of oospores. The results are given in Table I.

TABLE I *Response to change in food in oospore production by P. arecae and Jack-Fruit Phytopathora*

Name of culture	Year of isolation	Date of mating or subculturing	Date of examination	Oospore production on Quaker oat agar	Oospore production on Quaker oat agar by cultures after passing through hosts	Oospore production on French-bean agar
P. arecae	1943	Mated on January 17, 1946	January 25, 1946	None	Innumerable	Innumerable
P. arecae	1943	Mated on January 17, 1946	April 8, 1946	Few	Innumerable	Innumerable
Jack-Fruit *Phytophthora*	1942	Subcultured on January 17, 1946	January 25, 1946	None	Innumerable	Innumerable
P. arecae	1942	Mated on January 17, 1946	January 25, 1946	Fair	Innumerable	Innumerable
P. arecae	1946 (Fresh tissue cultures).		The strains readily yielded abundant oospores on the third or fourth day from mating.	Innumerable	—	Innumerable

It will be seen from the table presented that (1) the Tyagli-Nilekani subcultures as also the subculture of Jack fruit *Phytophthora* which had lost their capacity to oospore formation on Quaker oats agar as a result of continuous subculturing for 3 to 4 years regained the capacity for copious production of oospores when passed through their respective host tissues in a living state;

(2) the subcultures responded in a similar manner to a change in the medium viz French-bean agar;

(3) there is a progressive decline in the capacity to form oospores when continuously maintained on Quaker oat agar and finally this capacity is completely lost.

The few oospores formed on Quaker oats agar by the strains of *P. arecae* isolated in 1943, appear after considerable time from mating (about 3 months) as against a copious and prompt production on the 3rd or 4th day when the strains are renovated or freshly isolated.

Deterioration of the male or female strain during subculturing

Narsimhan (1930) reported that *P. meadii* obtained from the Division of Mycology, Imperial Agricultural Research Institute, Pusa, failed to produce oospores although abundant oospore production had been reported previously. He then mated *P. meadii* and *Phytophthora* isolated from sandalwood with *P. arecae* and obtained oospores readily. Later, he mated *P. meadii* with the isolation from sandalwood and obtained negative results. He considered P. *arecae* to be male, and concluded that the male strain in P. *meadii* had deteriorated and that the culture of *P. meadii* and the sandalwood isolate of *Phytophthora* represented female strain.

The writer obtained a culture of *P. meadii* from the same source and observed that it did not support any oospore formation. However, on mating it on French bean agar with + and − (or Tyagli and Nilekani) strains of *P. arecae*, abundant oospore production was observed showing the presence of both the male and female strains in isolate of P. *meadii*. This culture was kept under observation for a long time when it was found that oospore production had gradually decreased.

In order to find whether one of the two strains is lost on continuous transfer, a mixed culture of the heterothallic strains (Tyagli and Nilekani) of P. *arecae* was successively transferred on French bean agar for 10 generations at an interval of 10-30 days. The results are given in Table II.

TABLE II.

Observations on mixed heterothallic culture of P. arecae for oospore production

Generation No.	Date of transfer	Date of examination	Oospore formation
1	July 8, 1946	July 25, 1946	Fair
2	July 25, 1946	August 10, 1946	Abundant
3	August 10, 1946	August 22, 1946	Abundant
4	August 22, 1946	September 2, 1946	Abundant
5	September 2, 1946	September 12, 1946	Good
6	September 12, 1946	September 26, 1946	Fair
7	September 26, 1946	October 7, 1946	Good
8	October 7, 1946	November 8, 1946	Abundant
9	November 8, 1946	November 18, 1946	Abundant
10	November 18, 1946	December 4, 1946	Abundant

The fungus from the tenth generation was subcultured on oat meal agar and yellow corn meal agar on January 7, 1947 and examined on January 23, and February 1, 1947 when it was found that occasional oospores had formed on oat meal agar but none on yellow corn meal agar. These when again subcultured on French bean agar, showed profuse production of oospores on examination, showing conclusively that the production of oospores was dependant on the type of nutrition available.

It also shows that there exists no evidence to suggest the loss or deterioration of one or the other sex during the process of subculturing and that the Tyagli-Nilekani combination of *P. arecae* continued to form oospores unabated throughout the ten generations on French-bean agar.

SUMMARY

Heterothallic strains of *P. arecae* which were supposed to have lost their capacity for oospore production, could be restored to their original capacity to produce oospores copiously by passing them through live host tissue, i. e. by feeding them on their natural food or by culturing them on French-bean agar.

A subculture of an isolate of *Phytophthora* from Jack fruit could be similarly induced to form abundant oospores.

A subculture of *P. meadii* which had lost its capacity to form oospores started forming them but sparingly and after considerable time when grown on French bean agar.

Loss in ability to form oospores during the process of subculturing by a species of *Phytophthora* appears to be due to lack of favourable nutrition.

There is no evidence to suggest that the loss of fertility is due to deterioration of one or the other sex.

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XANTHOMONAS BADRII SP. NOV., ON *XANTHIUM STRUMARIUM* L. IN INDIA

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Xanthium strumarium L., a common annual weed is found growing along the banks of rivers, roadside and low lying places throughout the hotter parts of India where its fruits are known to many villagers for their medicinal value. A bacterial blight was first noticed on these plants on and around the Government Farm, Jalgaon, in August 1948 since when it had been found at several places all over the State The pathogen was easily isolated by ordinary agar-poured plate method and studied in detail in the laboratory, since no bacterial blight has so far been reported on this host.

Symptoms.—The pathogen enters the leaf through hydathodes where it produces irregular, pale yellow spots on the leaf-borders. The spots gradually increase in size when the central portion becomes deep brown accompanied by a yellow border. In severe cases of attack, the entire leaf-border gets infected and the leaf shrivels, droops and dies. Under ideal conditions of humidity and temperature, the infection becomes systemic as the organism migrates to the leaf-veins and makes its way as far as the stem through leaf-petioles. Wilting of young plants from the top downward is not uncommon. No water-soaked areas are noticeable. The incubation period at 23°-28°C is generally 7 days.

Morphology.—The organism is a short rod, single, rarely in chains, gram-negative, not-acid fast, non-spore former, motile by a polar flagellum, yellowish and stains readily with common dyes. In 48 hour old culture grown on potato dextrose agar at 31°C, the size of cells is 1.6 (1 4 to 1.8)×0.8 (0.7 to 1.0) μ.

Cultural and Physiologicial Characters.—On potato dextrose agar plates, the colonies are round, smooth, glistening, capitate with entire margins, 0.8 to 1 0 cm. in diam. after 4 days, colour empire yellow (Ridgway); on slants, growth copious, raised, smooth, glistening, filiform, opalescent, butyrous colour baryta yellow(Ridgway); on potato cylinders, growth copious, raised, flowing, shining, covering the entire surface in 4 days, colour turning dark brown in 8 days. On nutrient agar plates, colonies slow in growth, smooth, glistening with entire margins, 7 mm. in 4 days, the inner 6 mm. of the colony pale yellow while the outer 1 mm. border of the colony empire yellow (Ridgway); on slants, growth poor, slightly raised, dull, filiform, opalescent with no distinctive colour; in broth, good cloudy growth in 24 hours but no floccules. Plain milk almost cleared in 8 days. Litmus almost reduced in 8 days. Gelatin liquefied, starch

attacked, casein digested. Acid but no gas in dextrose, lactose, mannitol, salicin and sucrose. M. R. and V. P. tests negative. Nitrates not reduced, indol not produced, ammonia produced, Loeffler's blood serum slowly liquefied. Thermal death point about 51°C.

HOST RANGE.—Several related and unrelated plants were slightly wounded and kept under moist chambers before and after inoculation. The pathogen failed to infect *Pennisetum typhoideum*, *Oryza sativa*, *Avena sativa*, *Triticum vulgare*, *Sorghum vulgare*, *Hordeum vulgare*, *Zea mays*, *Lycopersicum esculentum*, *Gossypium* sp., *Lathyrus sativus*, *Crotalaria juncea*, *Arachis hypogoea*, *Chrysanthemum* sp., *Aster* sp., *Zinnia* sp., *Lactuca sativa*, *Sonchus* sp., *Helianthus annus*, *Eclipta erecta* and *Bindens pilosa* in repeated trials but produced typical blight on *X. strumarium* and spots on *Pisum sativum*.

IDENTITY OF THE ORGANISM.—Since no bacterial blight or leaf-spot has ever been reported on species of *Xanthium* or members of the family Compositeae and since it differs from other yellow phytopathogenic bacteria in its host range and cultural character, it is considered to be new to science and it is proposed to name it *X. badrii* after Dr. Badri Nath Uppal.

Xanthomonas badrii sp nov. short rods, 1.6 (1.4 to 1.8) u × 0.8 (0.7 to 1.0) μ; Motile with a polar flagellum; Gram-negative; Not acid fast; No spore; Growth fair, smooth, yellow, filiform on nutrient agar slants. Litmus reduced. Casein digested. Starch attacked. M. R. and V. P. tests negative. Loeffler's blood serum slowly liquefied Produces acid but no gas in dextrose, lactose, mannitol, salicin and sucrose. Optimum temperature for growth is 31°C ,while thermal death point about 51°C. Pathogenic to *Xanthium strumarium* and *Pisum sativum*.

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NOTES ON MISCELLANEOUS INDIAN FUNGI. I

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The object of this series of papers is to publish accounts of miscellaneous Indian fungi that are new records for India or new species, or new host records of some old well known ones, which may become available from time to time. The present contribution, the first of the series, gives description of 18 specimens. The new ones are illustrated with suitable diagrams where-ever possible.

1. **Myriangium duriaei** Mont. and Berk. in *Jour. Bot.* **4**; p. 72, 1845; Butler and Bisby, *Sci. Monogr. Coun. Agric. Res. India*, **1**, p. 30, 1931; Miller, *Mycologia* **32**: p. 590, 1940.

Stroma black, flat to convex, orbicular, 2-7 mm. diam., erumpent, superficial, gregarious, subglobose, pulvinate; fertile region bearing apothecia undifferentiated, disc shaped, marginate, pale within; *asci* in single locules, irregularly placed at different levels, 35–40 x 32–35 μ, globose or subglobose, with thick hyaline wall, 8 spored; *ascospores* oblong or elliptical, both ends round, hyaline, muriform, with 5-6 transverse septa and 1-3 longitudinal septa, 18–22 x 10–12 μ.

On scale insect on *Morus alba* Linn., Kalimpong, Darjeeling, July, 1948 (S. P. Raychaudhuri).

Butler and Bisby record this fungus on dead fallen branches (host plant not indicated) collected at Pusa in 1910. A re-examination of the specimen shows the remnants of some scale like insect below the fungal growth but it has not been possible to get the parasitised insect identified.

2. **Puccinia cynodontis** Lacroix in Desm. *Pl. Crypt.* **II**, p. 655, 1859; Butler and Bisby, *Sci. Monogr. Coun. Agric. Res. India*, **I**, p. 66, 1931; Arthur, *Manual of the Rusts in United States and Canada*, p. 169, 1934.

Uredia foliicolous, dull brown, linear to elliptic, seldom globose; *Urediospore* round, yellow ochre; epispore prominent, light Amber brown, wall uniformly thick, smooth; 22–33 x 19–26 μ mostly 25–28 x 22–26 μ with 2-3 germ pores; *Telia* foliicolous, elliptic, Mummy brown; *Teliospores* bicelled, xanthine orange, upper cell bigger than lower, epispore thick, Amber brown, thicker toward apex, slightly constricted at septum; septum prominent; stalk subhyaline, long, attachment central or slightly on one side, 30–36 x 26–30 μ, mostly 34–36 x 26–28 μ.

On leaves and leaf sheaths of *Cynodon plectostachyum* Plig., Botanical area, I.A.R.I. New Delhi, 28-1-49 (Girdhari Lal).

The previous record of this fungus in India is on *Cynodon dactylon.*

3. **Endothiella robiniae** sp. nov. (Fig. 1)

Pycnidia mostly single, rarely gregarious, erumpent, globose, pulvinate, slate black, 0.75–1.5 mm. in diameter, stromatic, parenchymatous, yellowish within, 500–900 μ, truncate, innate-erumpent, epidermis rupturing, fertile region above, 300-400 μ broad, separated from the rest of stroma by a dark brown layer; multilocular; *Conidiophores* flexuosus, hyaline, ramose with conidia borne at the tips, 92–185 x 1.5 μ; *Conidia* oblong, ovate, single celled, subhyaline, some times slightly curved, 5–8 x 1–1.5μ.

On dead twigs of *Robinia pseudo - acacia* L., Flowerdale, Simla, 12.xi.48 (R. L. Munjal). Type specimen deposited in Herb. Crypt. Ind. Orient., Indian Agric. Res. Institute, New Delhi.

Pycnidia ut plurimum singula, raro gregaria, erumpentia, globosa, pulvinata, atro-ardesiaca, 0.75–1.5 mm. diam., stromatica, parenchymatica, intus luteola, 500–900 μ, truncata, innatoerumpentia, epidermide sese scindente; regio fertilis plus 300–400 μ lata, a reliquo stromate separata per stratum obscure brunneum, multilocularis. *Conidiophori* flexuosi, hyalini, ramosi, ad apices oranti conidiis, 92–185 x 1.5 μ. *Conidia* oblongo-ovata, 1-cellulata, subhyalina, nonnumquam tenuiter curvata, 5–8 x 1–1.5 μ.

In surculis emortuis *Robiniae pseudo-acaciae* Linn., Flowerdale, Simla, 12.xi.48 (R. L. Munjal). Typus positus in Herb. Crypt. Ind. Orient., I.A.R.I., New Delhi.

4. **Darluca genistalis** (Fr.) Sacc. in *Mich.* **2**, p. 108, 1882; Saccardo, *Sylloge Fung.*, **3**, p. 410, 1884.

Pycnidia uredicole, Blackish brown, forming a crust, gregarious, rarely single, leathery; Pycnidial walls uniting, giving a stromatic appearance; globose 70–76 μ; *Conidia* straight, fusoid, hyaline, bicelled, rarely slightly constricted at the septum, setulose, 13–16 x 3 μ.

On uredia of *Puccinia cynodontis* Lacroix on *Cynonod plectostachyum* Plig., Botanical Area, I.A.R.I. New Delhi, 8.ii.49 (R. L Munjal).

5. **Septoria acteosae** Oud. in *Contrib. Fl. myc. Pays. Bas*, **15**, p. 16 *Hedw.*, **33**, p. 20, 1894; Saccardo, *Sylloge Fung.*, **11**, p. 545, 1895.

Spots round with light garnet brown margin in young spots, fading to Russet in older spots and straw coloured centres, 5–10 mm. in diameter; *Pycnidia* numerous, minute, dot like, globose, black, on straw coloured older portion of spot, amphigenous, 100–200 μ, wall membranous, parenchymatous. *Conidia* hyaline, 2-3 septate, usually curved, both ends rounded, sometimes one end acute, 46–60 x 3 μ, mostly 45-55 x 3 μ. Borne on inner roundish cells of pycnidial wall.

On leaves of *Rumex hastatus* D. Don, Flowerdale, Simla, 20.xi.48 (R. L. Munjal).

6. **Septoria achyranthis** sp. nov. (Fig 2).

Spots roundish with broad, reddish brown margins, 5-8 mm. in diameter, centre light coloured bearing pycnidia. *Pycnidia* epiphyllous, black, minute, separate, globose; ostiole broad; *Conidia* long, unseptate, curved at one or two points, upper end pointed, lower rounded, broader in the middle, hyaline, 45-55 x 3 μ, borne on hyaline, elliptic cells arising from the wall of pycnidium.

On leaves of *Achyranthes aspera* L., Flowerdale, Simla, 11.xi.48 (R. L. Munjal). Type specimen deposited in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

Maculae plus minus rotundatae marginibus rubro-brunneis, 5-8 mm. diam., centro pallide colorato atque pycnidiis. *Pycnidiis* ornato epiphyllis, nigris, minutis, separatis, globosis ostiolo lato; *Conidia* longa, haud septata, curvata uno vel utroque apice, superiore apice acuto, inferiore vero rotundato, latiora ad medium, hyalina, 48–55 x 3 μ, insidentia cellulis hyalinis ellipticis e pariete pycnidii surgentibus.

In foliis *Achyranthis asperae* Linn., Flowerdale, Simla, 11.xi.48 (R. L. Munjal). Typus positus in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

7. **Septoria geranii** Rob. *et* Desm. in *Ann. Sc. Nat. Bot.*, **20**, p, 93, 1853; Saccardo, *Sylloge Fung.* **3**, p. 514, 1884.

Spots irregular, coalescing, discoloured, tawny with broad reddish purple margin, 5–10 x 5 mm. *Pycnidia* minute, dot like, scattered throughout on the spot, globose, subepidermal, deeply seated in the tissue of the leaf, amphigenous, membranous; ostiole broad; *Conidia* hyaline, continuous, curved, filiform, both ends round, 29–50 x 1.5–2 μ, mostly 35–50 x 1.5 μ.

On leaves of *Fragaria indica* L., Flowerdale, Simla, 8.xi.48 (R.L. Munjal).

Two species of *Septoria*, *S. fragariae* Desm. and *S. aciculosa* Ell. *et* Everh., are recorded on *Fragaria*. The specimen under study differs from the former in having non-septate spores and from the latter in spore-size. It closely resembles *S. geranii* Rob. *et* Desm , which also appears to have been recorded earlier on a related host of the same family.

8. **Septoria polygonorum** Desm. in *Ann Sc. Nat.*, **17**, p. 108, 1842; Saccardo, *Sylloge Fung.* **3,** p. 555, 1884.

Spots roundish, small, separate, tawny with broad purple margin on the dorsal side, usually 4-8 mm. in diameter, with dot like pycnidia at centre. *Pycnidia* globose, epiphyllous, rarely hypophyllous, minute, innate, dark brown, seated in the palisade tissue; ostiole broad and round; *Spores* filiform, some what curved with 4-5 oil drops, hyaline, continuous, both ends acute, 17–26 x 1–1.5 μ, mostly 20–26 x 1.5 μ.

On leaves of *Polygonum recumbens* Royle, Flowerdale, Simla, 10. xi. 48 (R. L. Munjal).

9. **Septoria urticae** Desm. *et* Rob. in *Not.* **14**, p. 24, 1847; Saccardo, *Sylloge Fung.* **3**, p 557, 1884; Politic, *Mycologia*, 1935.

Spots small, roundish, dull brown, irregular, later with whitish centre, 4-6 mm. across, more prominent on upper surface of leaf; *Pycinidia* epiphyllous, subepidermal, numerous, separate, globose, black; *Conidia* usually curved, hyaline, flexuosus, mostly 35-48 x 2μ, continuous with 2-5 oil globules, both ends blunt.

On leaves of *Urtica dioica* Linn., Flowerdale, Simla, 13. xi. 48 (R. L. Munjal).

10. **Pleosphaeropsis anonae** sp. nov. (Fig. 3).

Pycnidia stromatic, valsoid, single or gregarious; innate, later erumpent, exposed part Blackish-brown, Peripheral region dark brown, interior lighter coloured; multilocular, 6-12 loculi, Paraphysate, Paraphyses thin, 1.5-2 μ broad; *Conidia* oblong or oval rarely globose, single celled, subhyaline when young, later chestnut, with one central oil globule, epispore darker, 12-20 x 9-13 μ.

On dead twigs of *Anona squamosa* L. Kumaon, 7. viii. 33 (U. B. Singh). Type specimen deposited in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

Pycnidia stromatica, valsoidea, singula, vel gregaria, innata, postea erumpentia, parte exteriore atreolo-brunnea, peripherali vero parte obscure brunnea, interiore vero pallidius tincta, multilocularia (loculis 6-12 praesentibus), paraphysata, paraphysibus tenuibus, 1.5-2μ lata, *Conidia* oblonga vel ovata, raro globosa, 1-cellulata, primo subhyalina, diende castanea, una olei globulo centrali oronata, episporio obscuriore, 12-20 x 9-13 μ.

In surculis emortuis *Anonae squamosae* Linn., Kumaon, 7. viii. 33 (U. B. Singh). Typus positus in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

11. **Pleosphaeropsis crotonis** sp. nov. (Fig. 4).

Pycnidia stromatic, valsoid, subepidermal, round, 0.5-1.5 mm. diameter, innate, erumpent, exposed part blackish brown; multilocular, 2-5 loculi, parenchymatous, Peripheral region dark brown, interior lighter coloured, walls of loculi fibrous, disintegrating later, ostiolate; Ostiole prominent; Paraphyses hyaline, filiform, flexuosus, 26-28 x 1 μ. *Conidia* oblong or oval, subhyaline when young, later chestnut, epispore smooth, spores laid in mucus, single celled, 10-16 x 10-12 μ.

On dead twigs of *Croton* sp. Pusa, Aug., 1916 (L. S. Mony). Type specimen deposited in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

Pycnidia stromatica, valsoidea, subepidermalia, rotunda, 0. 5-1.5 mm. diam., innata, erumpentia, parte exteriore atro-brunnea, multilocularia, loculis 2-5 praesentibus, parenchymatica, regione peripherali obscure brunnea, interiore vero pallidius tincta, parietibus loculorum fibrosis, postea dilabentibus, ostiolate, ostiolo eminenti; paraphyses hyalinae, filiformes, flexuosae, 26-28 x 1 μ. *Conidia* oblonga vel ovata, subhyalina primo, postea castanea, episporio laevi, sporis in muco positis et 1-cellulatis, 10-16 x 10-12 μ.

In surculis emortuis *Crotonis* cuiusdam, Pusa, Aug., 1916 (L. S. Mony). Typus positus in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

12. **Pleosphaeropsis cryptostegiae** sp. nov. (Fig 5).

Pycnidia stromatic, innate, subepidermal, usually globose, minute, hardly 0.5-1.0 mm. diameter, later erumpent; opening small, circular, prominent; exposed portion blakish brown; parenchymatous with dark brown peripheral region and olive brown interior, multilocular, 3-6 loculi, walls of loculi fibrous; Paraphyses thin, dissolving with age. *Conidia* when young, olivaceous, later chestnut, 15-18 x 9-12 μ, single celled with oil globule; epispore smooth, 2-3μ thick, prominent.

On dead twigs of *Cryptostegia grandiflora* Br., Lahore, 21.vii.39 (Director, Botanical Department, Punjab University). Type specimen deposited in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

Pycnidia stromatica, innata, subepidermalia, ut plurimum globosa, minuta, vix 0.5–1.0 mm. diam., postea erumpentia, foramine parvo, circulari, prominenti, regione externa atrobrunnea, parenchymatica, regione peripherali obscure brunnea, regione vero interiore olivaceo-brunnea, multilocularis, loculis 3-6 praesentibus, parietibus loculorum fibrosis; paraphyses tenues, vetustate dilabentes; novella conidia olivacea, postea castanea, 15–18 x 9–12 μ, 1-cellulata, uno olei globulo ornata; episporium laeve, 2-3 μ crassum, prominens.

In surculis emortuis *Cryptostegiae grandiflorae* Br., Lahore, 21.vii.39 (Director, Botanical Department, Punjab University). Typus positus in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

13. **Pleosphaeropsis dalbergiae** Died. in *Ann. Mycol.* **14**. p. 203, 1916; Saccardo, *Sylloge Fung.* **25**, p. 250, 1931; Butler and Bisby, *Sci. Monogr. Coun. Agric. Res. India*, **1**, p. 162, 1931.

Pycnidia stromatic, dark brown, erumpent, separate, or gregarious, subepidermal, 2-3 mm. diam., multilocular, wall many celled thick: *Conidiophores* single celled, hyaline, mixed with long, thin, hyaline, flexuosus paraphyses, 30–42 x 1.5 μ, paraphyses dissolving later. *Conidia* single celled, oblong or ovate, subhyaline or dark, both ends round, 15–21 x 10–13 μ. Epispore prominent, thick and darker. Spores laid in mucus.

On dead twigs of *Dolichos lablab* Linn., Botanical area, I.A.R.I. New-Delhi, Aug., 1948 (R. L. Munjal).

Previously this fungus is reported on *Dalbergia sissoo* only and this is a new host record..

14. **Pleosphaeropsis fici** sp. nov. (Fig. 6).

Pycnidia stromatic, valsoid, subepidermal, innate, later erumpent, black, globose or subglobose, separate or gregarious, 0 5–1.5 mm. in diameter, parenchymatous, light brown within and dark brown outside, multilocular, 1-6 loculi, walls of loculi fibrous, later disintegrating; Paraphyses hyaline, thin, 40–59 x 1–1.5 μ. *Spores* oblong or oval, both ends round, single celled, chest-nut, epispore darker and finely verrucose, 12–16 x 9–13 μ.

On dead twigs of *Ficus* sp. Ganesh Khand Botanical Gardens, Poona, Aug., 1921 (S. L. Ajrekar). Type specimen deposited in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

Pycnidia stromatica, valsoidea, subepidermalia, innata, postea erumpentia, nigra, globosa vel subglobosa, seprata vel gregaria, 0.5–1.5 mm. diam., parenchymatica, intus pallide brunnea, extus obscure brunnea, multilocularia, 1-6 loculata, parietibus loculorum primo fibrosis, postea dilabentibus; paraphyses hyalinae tenues, 40–59 x 1–1.5 μ; *Sporae* oblongae vel ovatae, utroque apice rotundato, 1-cellulatae, castaneae; episporium obscurius atque minute verruculosim, 12–16 x 9–13 μ.

In surculis emortuis *Fici* cuiusdam, Ganesh Khand Botanical Gardens, Poona, Aug., 1921 (S. L. Ajrekar). Typus positus in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

15. **Pleosphaeropsis psidii** sp. nov. (Fig 7)

Pycnidia stromatic, single or gregarious, subepidermal, innate-erumpent; opening small, circular, prominent, dark grey; globose or subglobose, parenchymatous with dark brown peripheral region outside and light brown within, multilocular, 3-6 loculi with fibrous walls, paraphysate; paraphyses filiform, sometimes clavate, dissolving with age, guttulate, hyaline; *Spores* single celled, oblong, liver brown, epispore smooth, prominent, 16–22 x 12 μ.

On dead twigs of *Psidium guyava* L., Ganesh Khand Botanical Gardens, Poona, Aug., 1921 (S. L. Ajrekar). Type specimen deposited in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

Pycnidia stromatica, singula vel gergaria, subepidermalia, innato-erumpentia; formanine parvo circulari, prominentia, obscure grisea; globosa vel subglobosa, parenchymatica, regione externa obscure brunnea, interiore vero pallide brunnea, multilocularia, loculis 3-6 praesentibus fibrosis, paraphysata; paraphysibus filiformibus nonnumquam clavatis vetustate dilabentibus, guttulata, hyalina; *Sporae* 1-cellulatae, oblongae, lividobrunneae; episporium laeve, prominens, 16–22 x 8–12 μ.

In surculis emortuis *Psidii guyava* Linn., Ganesh Khand Botanical Gardens, Poona, Aug., 1921 (S. L. Ajrekar). Typus positus in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

16. **Pleosphaeropsis thevetiae** sp. nov. (Fig 8).

Pycnidia stromatic, valsoid, innate, subepidermal, later erumpent,

gregarious, slate black, subglobose to oval, 0.75-2.0 mm. in diameter, pulvinate multilocular, 3-12 loculi, in one or two layers. Ostiole prominent, one or sometimes two in each pycnidium. Stroma parenchymatous with thick walled dark brown peripheral region and lighter brown interior; walls of loculi fibrous disintergrating later; Paraphyses thin, flexuosus dissolving with age; *Spores* when young embeded in mucus, single celled, oblong or oval, light chestnut 12-18 x 10-11 μ; epispore thick, smooth, prominent dark.

On dead twigs of *Thevetia nerifolia* Juss., Mycological area, I. A. R. I., New Delhi, Jan., 1949 (Girdhari Lal). Type speeimen deposited in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

Pycnidia stromatica, valsoidea, innata, subepidermalia, postea erumpentia, gregaria, atro-ardesiaca, subglobosa ad ovata, 0.75-2.0 mm. diam., pulvinate, multilocularia, loculis 3-12 praesentibus strato simplici vel duplici. Ostiolum eminens, unum vel nonnumpuam duo in singulis pycnidiis. Stroma parenchymaticum, regione peripherali obscure brunnea parietibus crassis, inetiore vero pallidius brunnea; loculorum parietes fibrosi, postea dilabentes; paraphyses tenues, flexuosae, sese dissolventes vetustatae; *Sporae* nonvellae muco circumdatae, 1-cellulatae. oblongae vel ovatae, pallide castaneae, 12-18 x 10-11 μ; episporio crasso, laevi, prominenti, obscuro.

In surculis emortuis *Thevetiae nereifoliae* Juss; in loco "Mycological area" in I. A. R. I., New Delhi, Jan., 1949 (Girdhari Lal). Typus positus in Herb. Crypt. Ind. Orient., Indian Agric. Research Institute, New Delhi.

17. **Diplodia profusa** De Not. in *Micr. Ital. Dec.* **4**, n. 8; Saccardo, *Sylloge Fungorum* **3**, 336, 1884.

Pycnidia numerous, dark, gregarious, subepidermal usually below the bark, innate-erumpent, ostiolate, lighter coloured within, walls parenchymatous and dark brown, composed of closely compact cells. *Conidiophores* simple, hyaline, straight, somewhat pointed, at the apex, 10-12 x 1. 5-2 μ. *Conidia* at first hyaline and single celled, then dark brown, bicelled, oblong; septum and epispore darker, 16-22 x 6-9 μ, mostly 17-18 x 7-9 μ. Epispore thin, uniform, smooth.

On dead twigs of *Robinia pseudo-acacia* L., Flowerdale, Simla, 12. xi. 48 (R. L. Munjal).

18. **Spegazzinia oronata** Sacc. in *Mich.* **2**, p. 172, 1882; *F. ital. tab.* 920; *Sylloge Fung.* **4**, p. 758, 1886.

Sporodochia oblong or globose, 1 x 0. 5 mm., black. superficial, convex; *Conidiophores* dark brown, aseptate, generally curved, uniformly thick, variable in length, 52-108 x 3μ, mostly 70-90 x 3 μ, fasciculate, spreading above; *Conidia* Isabella coloured, 4 celled, echinulate with prominent, long, stout echinulations; later marsbrown, smooth walled, crucifix, septa cross-wise; constricted at the periphery, 13-18 μ (with echinulations 22-26μ.)

In one month old cultures on Potato dextrose agar conidia measure 14-18 μ (with echinulations 22-31 μ). Colonies cottony white when young, later creamish white with olivaceous centre. Sporodochia abundant, black, prominent, aerial, mostly in rings, some scattered. No pigmentation imparted to the medium.

On dead leaves of *Cynodon dactylon* Pers., Botanical area, I. A. R. I., New Delhi, 29. i. 48 (R. L. Munjal).

Grateful thanks are due to Dr. R. S. Vasudeva, Head of the Division, for his keen interest and valuable criticism. Thanks are also due to Dr. G. R. Bisby of the Commonwealth Mycological Institute for helpful suggestions. For the Latin translation of the descriptions we are indebted to Rev. Father H. Santapau, S. J., Head of the Dept. of Biology, St. Xavier's College, Bombay.

Division of Mycology and Plant Pathology,
Indian Agricultural Research Institute,
New Delhi

EXPLANATION OF PLATES

Fig. 1. *Endothiella robiniae*
(*a*) Stroma with Pycnidium x 32
(*b*) A part of Conidiophore showing attachment of Conidia x 575

Fig. 2. *Septoria achyranthis*
(*a*) Pycnidium x 290
(*b*) Conidia x 290

Fig. 3. *Pleosphaeropsis anonae*
(*a*) Pycnidium x 70
(*b*) Conidia x 290

Fig. 4. *Pleosphaeropsis crotonis*
(*a*) Pycnidium x 70
(*b*) Conidia x 290

Fig. 5. *Pleosphaeropsis cryptostegeae*
(*a*) Pycnidium x 70
(*b*) Conidia x 290

Fig. 6. *Pleosphaeropsis jici*
(*a*) Pycnidium x 70
(*b*) Conidia x 575

Fig. 7. *Pleosphaeropsis psidii*
(*a*) Pycnidium x 70
(*b*) Conidia x 290

Fig. 8. *Pleosphaeropsis thevetiae*
(*a*) Pycnidium x 70
(*b*) Condia x 290

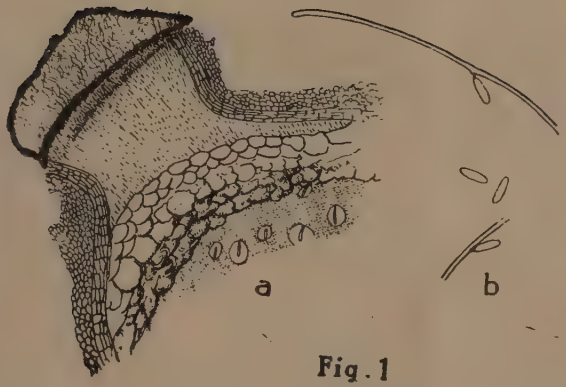


Fig. 1

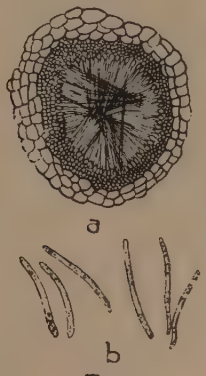


Fig. 2

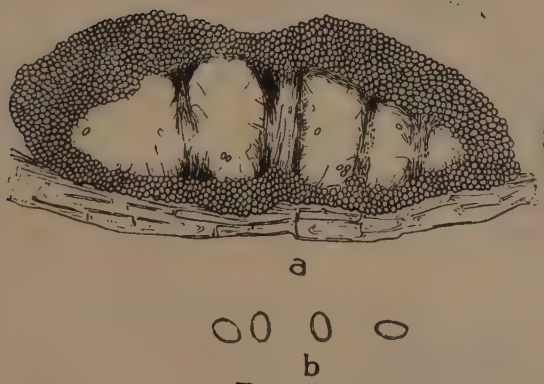


Fig. 3

Fig. 4

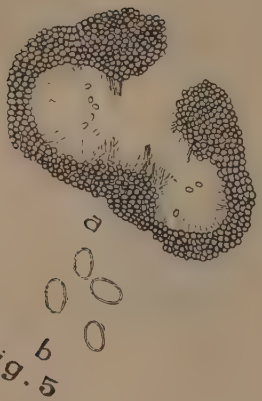


Fig. 5

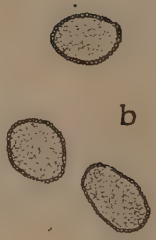
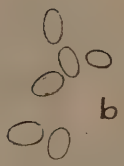


Fig. 6



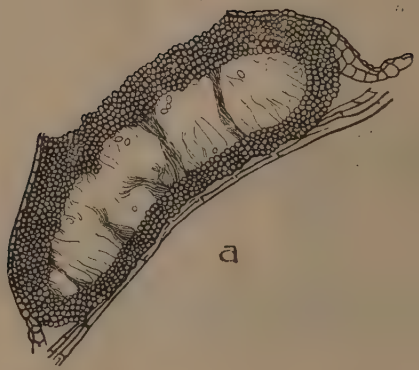
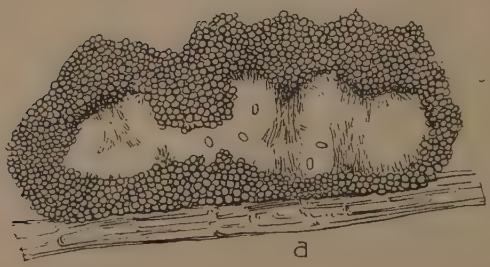


Fig. 7



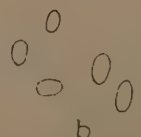


Fig. 8

MINUTES OF THE THIRD ANNUAL MEETING HELD ON JANUARY 3, 1950, AT 4.30 P.M. IN THE BOTANY SECTION ROOM OF THE INDIAN SCIENCE CONGRESS, FERGUSSON COLLEGE, POONA

The meeting was attended by 20 members and 10 visitors. Dr. S. R. Bose, President of the Society took the chair. In the absence of Dr. B. B. Mundkur, Dr. R. Prasada acted as the Secretary.

1. Minutes of the meeting held on 2.1.1949 were read and confirmed.

2. The following resolution was passed, all members standing :—

The members of the Indian Phytopathological Society place on record their deep sence of sorrow on the sad demise of Dr. U. B. Singh.

3. Report for 1942 was read and unanimously adopted. Dr. B.B. Mundkur's resignation from the office of Secretary-Treasurer was accepted.

4. The ballot papers were opened by Dr. R. P. Asthana and Mr. R. C. Lacy and the following office bearers were elected for 1950 :—

President	B. B. Mundkur
Vice-President	K. C. Mehta
Secretary-Treasurer	R. Prasada (1950-52)
Councillors :	
Northern Zone	B. L. Chona
Mid-Eastern Zone	P. R. Mehta
Eastern Zone	S. R. Bose
Central Zone	S. Vaheeduddin
Western Zone	M. K. Patel
Southern Zone	D. Marudurajan

5. It was unanimously resolved that whenever the sum to the credit of the Indian Phytopathological Society exceeds Rupees Three thousand and five hundred, then the extra sum be invested in National Cash Savings Certificates, leaving the balance of Rs. 3,500/- for current expenses.

6. The following resolution was unanimously adopted :—

The Indian Phytopathological Society resolves to put on record its profound appreciation of the services of Dr. B. B. Mundkur for his untiring efforts to successfully establish the Society and who now voluntarily retires

from the office of the Secretary-Treasurer. The Society undoubtedly owes its present status to his hard labour and keen interest.

7. Dr. S. R. Bose epened the discussion on 'Influence of Environment on Plant Diseases'. Drs. Saha, Nandy, Prasada, Kamat and Mohanty read papers and took part in the discussion. Dr. Mathur's paper was read by Dr. Saha in his absense.

8. It was approved that Dr. R. Prasada and Dr. B. L. Chona be authoriesed to operate the account in the Bank.

9. Vote of thanks to the retiring office bearers, to the Chairman of the meeting and to the authorities of the Fergusson College was unanimously passed.

THIRD ANNUAL REPORT OF THE INDIAN PHYTOPATHOLOGICAL SOCIETY

I am submitting herewith the Third Annual Report (for 1949) of the Indian Phytopathological Society. At the beginning of 1949 the membership was stated to stand at 201 of whom one was a patron, 26 life members and 174 ordinary members, one member resigned without paying his 1948 dues and 28 members failed to respond to numerous reminders for the payment of their 1948 subscriptions. They may be considered as having resigned the membership of the Society. The year thus actually began with 178 members. At the end of 1949 however there was one patron, 38 life members of whom five are paying their dues in instalments and 162 ordinary members. Of the latter, one died during the year and four have resigned their membership. This brings the total membership at the end of 1949 to 196 of whom 28 have yet to pay their 1949 dues. It is hoped that they will pay their dues, as early as possible.

Vol I No 1 and 2 of INDIAN PHYTOPATHOLOGY were published during the year and mailed to all the members. About 150 copies of Issue No 1 were sent to different Universities, Experiment Stations and Research Institutes as complimentary copies. A little later, bills were sent to all of them hoping that they would like to receive the future issues of the Journal for their libraries. I am glad to say that 43 Institutions have paid their subscriptions and about 20 are about to send their subscriptions or have the matter under consideration.

Vol II No 1 of INDIAN PHYTOPATHOLOGY which is for 1949 is now in the page-proof stage and it is hoped that it will be out by the end of March 1950. The press where the printing is being done has, however, abruptly raised its printing charges. Correspondence is going on with the press and unless a satisfactory solution is arrived at, it would not be possible to send manuscripts to that press and arrangements will have to be made with some other press for printing the Journal. The press also charged exorbitant rates for printing the reprints at which all the authors have strongly protested. This matter is also under correspondence. I am afraid our arrangements with the British India Press will have to be terminated as it is adopting a very unreasonable attitude. Their printing has also declined and the blocks for line drawings and half-tones have been most unsatisfactory in spite of the vigorous protests that I have made.

The year began with Rs. 8141/5/9. Of this ammount Rs. 5,000/- were invested in National Cash Certificates and the Securities have been deposited

with the Lloyds' Bank. The balance to the credit of the Society was transformed into a Saving Bank Account so that the money could earn some interest. Receipts during the year amounted to about Rs. 3462/12/- and the expenses incurred have amounted to Rs. 2051/12/9 which include the charges for printing Vol I No 1 of INDIAN PHYTOPATHOLOGY. No expenses were incurred during the year on clerical help, but the accounts for the years 1947 and 1948 were audited by a Chartered Accountant at a cost of Rs. 50/-. A statement of Receipts and Expenditure for 1949 has been prepared but it has not been audited as the Hon'y Auditor, Dr. S. P. Rai Chowdhury, elected last year at Allahabad, was away on leave. I think the best thing would be to get the accounts for 1949 also properly audited by a Chartered Accountant. I must mention in this connection that several American cheques are still in the process of collection and the sum in the Savings Bank Account of the Society may actually be a little more. On December 23, 1949 the sum to the credit of the Society was Rs. 4,495/12/7 and cash in hand on the same date was Rs. 84/6/6. When the accounts are audited, the balance sheet will show the precise sums collected and spent and I have no doubt that the balance sheet will be published in an issue of the INDIAN PHYTOPATHOLOGY.

In July 1949 I applied for subsidies, to print the Society's Journal, to the National Institute of Sciences of India and also the Indian Council of Agricultural Research. I have been informed demi-offically that a sum of Rs. 200 has been sanctioned by the National Institute of Sciences and another sum (the precise amount unknown) has been sanctioned by the Indian Council of Agricultural Research. This Council stated that the Society should be registered under the Indian Companies Act before the subsidy would be made available and the Society was, therefore, registered at a cost of Rs. 50/- with the Registrar of Joint Stock Companies Delhi Province.

It is expected that the charges for printing two isssues of INDIAN PHYTOPATHOLOGY will amount to not less than Rs. 2,800/- a year and it will not be possible to meet this expenditure unless there is a large membership and a greater number of subscribers. I regret to say that many of the Universities, Institutes and Colleges in India have not yet subscribed to the Journal of the Society. Unless the members help the Secretary-Treasurer by striving to get more members and more subscribers to the Journal, it will not only be not possible to increase the number of issues per volume but even to get two issues printed. I, therefore, hope that the new Secretary-Treasurer will be helped by all the members in securing not only more members and more subscribers but subsidies from the Universities and donations from those who may be inclined to help the Society.

The numbers of articles received for publication in Vol I No 1 and 2 and Vol II No 1 and 2 was satisfactory. But no articles have yet been received for Vol III No 1 as they have to go to the press by the end of March 1950. Unless suitable and good articles are sent by the members it will not be possible to keep INDIAN PHYTOPATHGLOGY alive. In any case the standard of the Journal must be kept very high and all articles that may be sent by members should be carefully scrutinised before they are published. I hope that the Editorial Board will always keep this high standard in mind.

During the year Dr. R. Prasada helped me considerably with the work of the Society for which I must express my thanks to him. Encouragement, suggestions and help were also received from Dr. S. R. Bose. President of the Society, to whom I wish to express my gratitude.

B. B. MUNDKUR
Secretary-Treasurer

THE INDIAN PHYTOPATHOLOGICAL SOCIETY, DELHI.

Receipts and Payments Account for the Year Ended 31st December, 1949.

RECEIPTS	Rs.	AS.	P.	Rs.	AS.	P.
To Opening Balance:						
Cash in hand ...	92	13	9			
Balance with Lloyds Bank Ltd., New Delhi ...	8,048	8	0	8,141	5	9
„ Admission Fees ...				210	0	0
„ Life Membership Fees ...				810	0	0
„ Subscription: ...						
For 1948 ...	210	0	0			
For 1949 ...	1,106	6	0			
For 1950 ...	70	0	0			
For 1951 ...	20	0	0	1,406	6	0
„ Donations ...				10	0	0
„ Subscriptions (Indian Phytopathology) ...				788	7	7
„ Cost of Reprints (net) ...				183	3	0
„ Advertising Charges ...				108	0	0
„ Interest on Savings A/c. ...				24	9	0
„ Difference in Exchange ...				45	11	0
				11,727	10	4

PAYMENTS	Rs.	AS.	P.	Rs.	AS.	P.
By National Savings Certificates				5,000	0	0
„ Printing and Stationery ...				1,644	13	0
„ Postage ...				147	0	9
„ Audit Fees ...				50	0	0
„ Registration Fees ...				50	0	0
„ Bank Charges (Net) ...				31	15	0
„ Miscellaneous Expenses ...				41	5	0
„ Balance: ...						
Cash in hand ...	72	7	0			
Balance with Lloyds Bank Ltd., New Delhi ...	4,690	1	7	4,762	8	7
				11,727	10	4

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BOOK REVIEW

AN INTRODUCTION TO PLANT PHYSIOLOGY

By Otis F. Curtis & Daniel G. Clark, Publishers: Mc. Graw-Hill Book Co., Inc., New York. 6. 50. Pp. VIII 752. 1950.

This textbook is intended for students taking a first course in Plant Physiology and who have some acquaintance with botanical and chemical principles. In the treament of the subject the biochemical aspects are given secondary importance to ecological and physiological, since the latter are more easily developed without referance to advanced chemical principles and yet have an important bearing on horticultural and agronomical practices.

The explanation of physiological phenomena is particularly beset with the difficulty that in a living organism, be it uni-or-multicellular, a host of interrelated processes occur simultaneously and those of immediate interest to an investigator cannot be completely isolated from the rest. Cultivation of a sense of critical interpretation of the data is, therefore, particularly essential for a student of plant physiology. In this connection the authors have rendered a very valuable service by giving a clear and interesting exposition of the technique of critical evaluation of experimental evidence and general sets of test question. Not only students but also young investigators and teachers would do well to grasp thoroughly the material given in the Introduction and Appendices I, II and IIb.

The treatment of all important phases of Plant Physiology and of recent developments is very lucid and sustains interest throughout. The authors have been guided by the principle that a somewhat more critical handling of fewer topics is more useful than a presentation of greater range of facts. According to this sound principle the choice of data for illustrative purposes must necessarily depend upon individual taste and as such, the reviewer refrains from pointing out omissions of certain topics which he would have liked to be included.

The get-up of the book, on the whole, is excellent.

R. D. Asana

INDIAN PHYTOPATHOLOGICAL SOCIETY

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Authors are invited to consult Bisby's 'An Introduction to Taxonomy and Nomenclature of Fungi' (1945), pp. 38-41 and Riker's 'The Preparation of manuscripts for *Phytopathology*', *Phytopathology* **36 :** 953-977, 1946, before preparing their mss. and figures.

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